Instruction Manual
Model 195A
Digital Multimeter

Cleveland, Ohio, U.S.A.
Document Number 195A-901-01

SPECIFICATIONS

DC VOLTS

(5½ Digits)

RANGE	RESO-LUTION	INPUT RESISTANCE	ACCURACY†‡ ±(%rdg + counts) 24Hr., 23°±1°C	1 Yr., 18°-28°C	TEMPERATURE COEFFICIENT ±(%rdg+counts)/°C 0°-18°C & 28°-50°C
20mV	100 nV	>1GΩ	0.01+40	0.025+40	0.003+2
200mV	1 μV	>1GΩ	0.01+ 6	0.025+ 6	0.003+0.5
2 V	10 μV	>1GΩ	0.01+ 8	0.020+ 8	0.003+0.5
20 V	100 μV	10MΩ	0.01+ 6	0.030+ 6	0.003+0.5
200 V	1mV	10MΩ	0.01+ 8	0.025+ 8	0.003+0.5
1000 V	10mV	10MΩ	0.01+ 6	0.025+ 6	0.003+0.5

†After pushbutton or bus zeroing.
‡In 4½ digit mode, counts = ±2 (except ±4 on 20mV range after zeroing).
NMRR: Greater than 60dB at 50 or 60Hz.
CMRR: Greater than 120dB at DC and 50 or 60Hz (with 1kΩ in either lead).
MAXIMUM ALLOWABLE INPUT: 1000V peak.
BENCH READING RATE: 5 readings/second.

OHMS

(5½ Digits)

RANGE	RESO-LUTION	OUTPUT I short	Vopen	ACCURACY†‡ ±(%rdg + counts) 24Hr., 23°±1°C	1 Yr., 18°-28°C	TEMPERATURE COEFFICIENT ±(%rdg+counts)/°C 0°-18°C & 28°-50°C
20 Ω	100 μΩ	- 2mA	-2V	0.015+25	0.025+25	0.003+2
200 Ω	1mΩ	- 2mA	-2V	0.015+ 7	0.025+ 7	0.003+0.5
2 kΩ	10mΩ	- 2mA	-2V	0.015+ 5	0.022+ 5	0.003+0.5
20 kΩ	100mΩ	- 20 μA	-2V	0.015+ 7	0.025+ 7	0.003+0.5
200 kΩ	1 Ω	- 20 μA	-2V	0.015+ 5	0.022+ 5	0.003+0.5
2MΩ	10 Ω	-200 nA	-2V	0.03 + 7	0.050+ 7	0.015+1
20MΩ	100 Ω	-200 nA	-2V	0.06 + 5	0.100+ 5	0.025+1

†After pushbutton or bus zeroing.
‡In 4½-digit mode, counts = ±2 (except ±4 on 20Ω range after zeroing).
CONFIGURATION: Automatic 2- or 4-terminal.
MAXIMUM ALLOWABLE INPUT: 360V peak or 250V rms.
BENCH READNG RATE: 3 readings/second except 20MΩ range, 1 reading/second.

TEMPERATURE

(5½ Digits)

SPAN	RESO-LUTION	4-WIRE ACCURACY[1] ±(%rdg+counts) 1 YR., 18°-28°C	TEMPERATURE COEFFICIENT ±(%rdg+counts)/°C 0°-18°C & 28°-50°C
°C			
-200.00° to 230.00°	0.01°	0.03 + 10	0.003 + 0.4
230.00° to 630.00°	0.01°	0.03 + 40	0.003 + 4
-220.00° to -200.00°	0.01°	0.03 + 40	0.003 + 4
°F			
-328.00° to 446.00°	0.01°	0.03 + 18	0.003 + 0.7
446.00° to 1100.00°	0.01°	0.03 + 72	0.003 + 7
-360.00° to -328.00°	0.01°	0.03 + 72	0.003 + 7

[1] Autorange mode, excluding probe errors.
RTD TYPE: 100Ω platinum; DIN 43 760 or IPTS-68, Programmable alpha and delta 3- or 4-wire.
MAXIMUM LEAD RESISTANCE (each lead): 4-wire: 25Ω.
3-wire: 15Ω.
SENSOR CURRENT: 1.0mA maximum, RMS.
BENCH READING RATE: 1.2 reading per second.
MAXIMUM COMMON MODE VOLTAGE: 500V (42V with Model 1951 connected).
COMMON MODE REJECTION: Less than 0.005°C/volt at DC, 50Hz and 60Hz (100Ω unbalance, LO driven).
MAXIMUM ALLOWABLE INPUT: 360V peak, 250V rms.

TRMS AC VOLTS (Option 1950)

(5½ Digits)

RANGE	RESO-LUTION	ACCURACY (1 Year)† ±(%rdg + counts) 18°-28°C 20Hz-45Hz	45Hz-10kHz	10kHz-20kHz	20kHz-50kHz
200mV*	1 μV	0.8+200	0.3+200	0.7+200	2.0+300
2 V	10 μV	0.8+200	0.3+200	0.7+200	2.0+250
20 V	100 μV	0.8+200	0.3+200	0.7+200	1.5+250
200 V	1mV	0.8+200	0.3+200	0.7+200	1.5+250
700 V	10mV	0.8+200	0.3+200	0.7+200	1.5+250

†In 4½ digit mode, divide count error by 10.
*Above 1mV.
TEMPERATURE COEFFICIENT (0°-18°C & 28°-50°C): Less than ±(0.1 × applicable accuracy specification)/°C.
RESPONSE: True root mean square, AC coupled.
CREST FACTOR (ratio of peak to rms): Up to 3:1 allowable.
INPUT IMPEDANCE: 2MΩ shunted by less than 75pF.
MAXIMUM ALLOWABLE INPUT: 1000V peak, 10^7V•Hz.
BENCH READING RATE: 3 readings/second.
CMRR: Greater than 60dB at DC, 50 or 60Hz (with 1kΩ in either lead).
BANDWIDTH: -3dB at 250kHz typical.

DC AMPS (Option 1950)

(5½ Digits)

RANGE	RESO-LUTION	ACCURACY (1 YEAR)†‡ ±(%rdg+counts) 18°-28°C	TEMPERATURE COEFFICIENT ±(%rdg+counts)/°C 0°-18°C & 28°-50°C	MAXIMUM VOLTAGE BURDEN
20 μA	100pA	0.14+40‡	0.01+2	0.03V
200 μA	1nA	0.09+10	0.01+0.5	0.25V
2mA	10nA	0.09+10	0.01+0.5	0.25V
20mA	100nA	0.09+10	0.01+0.5	0.25V
200mA	1μA	0.09+10	0.01+0.5	0.28V
2 A	10μA	0.09+10	0.01+0.5	1 V

†In 4½ digit mode, counts = ±2 (except ±4 on 20μA range after zeroing).
‡After pushbutton or bus zeroing.
OVERLOAD PROTECTION: 2A fuse (250V), externally accessible.
BENCH READING RATE: 5 readings/second.

TRMS AC AMPS (Option 1950)

(5½ Digits)

RANGE	RESO-LUTION	ACCURACY (1 YEAR)†* 45Hz-10kHz ±(%rdg+counts) 18°-28°C	TEMPERATURE COEFFICIENT ±(%rdg+counts)/°C 0°-18°C & 28°-50°C	MAXIMUM VOLTAGE BURDEN
200 μA	1nA	0.6+250	0.04+10	0.25V
2mA	10nA	0.6+250	0.04+10	0.25V
20mA	100nA	0.6+250	0.04+10	0.25V
200mA	1 μA	0.6+250	0.04+10	0.28V
2 A	10 μA	0.6+250	0.04+10	1 V

†In 4½ digit mode, divide count error by 10.
*Above 0.5% of range.
RESPONSE: True root mean square, AC coupled.
CREST FACTOR (ratio of peak to rms): Up to 3:1 allowable.
OVERLOAD PROTECTION: 2A fuse (250V), externally accessible.
BENCH READING RATE: 3 readings/second.

IEEE-488 BUS IMPLEMENTATION

Multiline Commands: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD.
Uniline Commands: IFC, REN, EOI, SRQ, ATN.
Interface Functions: SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.
Programmable Parameters: Range, Function, Zero, Integration Period, Averaging, EOI, Trigger, Terminator, Delay*, 100-rdg. Storage, Calibration, Display, Multiplex Off, Status, Service Request, Self Test, Output Format.
*First reading is correct when step input is coincident with trigger.

Conversion Rates (DC Volts):

USEABLE RESOLUTION	INTEGRATION PERIOD	TRIGGER TO FIRST BYTE OUT	MAXIMUM READING RATE†
3½ Digit	3.3 ms	17ms	76
4½ Digit	16.66ms‡	30ms	36
5½ Digit	100 ms	114ms	9

†Readings/second.
‡20ms at 50Hz.
Address Modes: TALK ONLY and ADDRESSABLE.

FRONT PANEL PROGRAMS

0 **Clear**—Cancels program mode.
1 **Non-Volatile RAM Storage**—Store programs 3, 4, 5, 6 and 8 data in NVRAM
2 **Multiplex**—Defeats input amplifier multiplexing.
3 **IEEE bus mode**—ADDRESSABLE and TALK ONLY entry.
4 **Line Frequency**—Selects 50Hz or 60Hz operation.
5 **Calibration**—Performs digital calibration.
6 **Temperature**—Allows °C and °F temperature measurements.
7 **Data Logger**—Allows 100-reading storage at 9 programmable rates; also stores highest, lowest and average reading.
8 **Diagnostics**—Troubleshooting aid and self-test.
9 **Trigger**—Enables front panel or external triggering.

GENERAL

DISPLAY: Six 0.5" LED digits with decimal point, exponent and polarity. Function and IEEE bus status also displayed.
RANGING: Manual or fast autoranging (150ms per range change on DCV).
ISOLATION: Input LO to IEEE LO or power line ground: 500V max, 5×10^5 V•Hz; greater than $10^9\Omega$ paralleled by 300pF.
WARMUP: 1 hour to rated accuracy.
OPERATING ENVIRONMENT: 0°-50°C, 0% to 80% relative humidity up to 35°C.
STORAGE ENVIRONMENT: -25° to 65°C.
POWER: 105-125V or 210-250V (internal switch selected), 50Hz to 400Hz, 24V•A maximum. 90-110V and 180-220V version available upon request.
CONNECTORS: Analog: Switch selectable front or rear, 5-way gold plated binding posts. **Digital:** Trigger input and Voltmeter Complete output on rear panel, BNCs.
DIMENSIONS, WEIGHT: 127mm high × 216mm wide × 359mm deep (5" × 8½" × 14 1/8 "). Net weight 3.2kg (7 lbs.).

Specifications subject to change without notice.

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SAFETY PRECAUTIONS

This instrument is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read over the manual carefully before operating this instrument.

Exercise extreme caution when a shock hazard is present at the instrument's input. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V rms or 42.4V peak are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Inspect the test leads for possible wear, cracks or breaks before each use. If any defects are found, replace with test leads that have the same measure of safety as those supplied with the instrument.

For optimum safety do not touch the test leads or the instrument while power is applied to the circuit under test. Turn the power off and discharge all capacitors, before connecting or disconnecting the instrument.

Do not touch any object which could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface, which is capable of withstanding the voltage being measured.

Exercise extreme safety precaution when testing high energy power circuits (AC line or mains, etc.).

Do not exceed the instrument's maximum allowable input as defined in the specifications and operation section.

SAFETY PRECAUTIONS FOR HIGH ENERGY CIRCUITS

To optimize safety when measuring voltage in high energy distribution circuits, read and observe the directions in the following warning.

WARNING

Dangerous arcs of an explosive nature in a high energy circuit can cause severe personal injury or death. If the meter is connected to a high energy circuit when set to a current range, low resistance range or any other low impedance range, the circuit is virtually shorted. Dangerous arcing can result even when the meter is set to a voltage range if the minimum safety spacing is reduced.

When making measurements in high energy circuits use test leads that meet the following requirements:

1. Test leads should be fully insulated.
2. Only use test leads that can be connected to the circuit (e.g. alligator or spade lugs) for a hands-off measurement.
3. Use test leads that do not reduce the arc protection by decreasing the voltage spacing between conductors or terminals.

Use the following sequence when testing power circuit:

1. De-energize the circuit using the regular installed connect-disconnect device such as the circuit breaker, main switch, etc.
2. Attach the test leads to the circuit under test. Use appropriate safety rated leads for this application.
3. Set the DMM to the proper function and range.
4. Energize the circuit using the installed connect-disconnect device and make measurements without disconnecting the DMM.
5. De-energize the circuit using the installed connect-disconnect device and make measurements without disconnecting the DMM.
6. Disconnect the test leads from the circuit under test.

SECTION 1
GENERAL INFORMATION

1.1 INTRODUCTION

The Model 195A Digital Multimeter is a fully programmable instrument with 5½ digit resolution. In standard configuration, the Model 195A is capable of DC voltage measurements between 100nV and 1000V on six ranges, 2-terminal and 4-terminal resistance measurements between 100$\mu\Omega$ and 20MΩ on seven ranges and temperature measurements in the range of -220°C and +630°C and between -360°F and +1100°F. The instrument is designed to work with platinum RTD probes, a factor which contributes to high accuracy.

With the optional Model 1950 ACV and AC and DC current option installed, the Model 195A can make TRMS AC voltage measurements between 1μV and 700V on five ranges, TRMS AC current measurements between 1nA and 2A on five ranges and DC current measurements between 100pA and 2A on six ranges. The versatility of the Model 195A DMM is further enhanced by the inclusion of a standard IEEE-488 interface. A highlight of Model 195A operation is its digital calibration feature which allows the user to easily perform calibration from the front panel.

1.2 MODEL 195A FEATURES

Some important Model 195A features include:

1. Standard IEEE-488 Interface. A standard IEEE-488 interface allows the Model 195A to be programmed from a system controller; readings may also be transmitted over the bus to other instrumentation in the talk-only mode.
2. Front Panel Programs. Numerous internal programs to control various operating modes such as digital calibration and IEEE-488 parameters are easily entered from the front panel.
3. Non-Volatile (NV) RAM Storage. A non-volatile RAM stores calibration constants, certain IEEE operating parameters, and line frequency values even when the power is turned off.
4. Digital Calibration. The Model 195A may be easily calibrated by applying an appropriate calibration signal and running the front panel calibration program or by commanding it over the bus. The calibration level may be at full range, or at some value entered from the front panel or over the IEEE bus.
5. Data Storage. A data storage buffer is included to allow up to 100 readings to be internally stored at a user-selected rate. The buffer may be read and controlled from the front panel or over the IEEE-488 bus. In the talk-only mode, the output rate can also be programmed.
6. Front and Rear Panel Input Terminals. Input terminals are duplicated on the front and rear panels to allow easy connections in both bench and rack-mounted situations. The selected set of inputs is controlled by the rear panel switch.
7. Trigger Input and Output. The Model 195A may be triggered to take readings by applying an external trigger pulse or by pushing a front panel button. A separate output pulse, which is active when the instrument completes a reading, is also available on the rear panel.
8. Auto Ranging. The Model 195A includes a fast auto ranging feature for easier measurements.
9. Front Panel Zero. A single front panel zero control allows the user to store a separate zero offset for each measuring function.
10. Filtering. Digital filtering is selectable from the front panel or bus.

Temperature measurement features include:

1. High Accuracy. Because platinum RTD probes have predictable resistance change with temperature and are highly linear, temperature measurements are made with a greater degree of accuracy than is possible with thermistor or thermocouple type probes.
2. Ease of Use. The temperature measuring mode is easily entered from the front panel or over the IEEE bus. Sophisticated software automatically measures the probe resistance and calculates the reading.
3. Dual Scale Temperature Measurements. Temperature readout may be obtained in either °C or °F. Readings are available on the display and over the IEEE bus.
4. Front Panel Calibration. Temperature calibration may be performed from the front panel. Probe errors can be minimized with the calibration procedure.
5. Four Wire Resistance Measurements. Resistance measurements using the 4-wire method minimize the effects of lead resistance.
6. Selectable 3-wire or 4-wire Operation. The instrument may be used with either 3-wire or 4-wire probes; the mode of operation is easily changed from the front panel.

1.3 WARRANTY INFORMATION

Warranty information may be found inside the front cover of this manual. Should it become necessary to exercise the warranty, contact the nearest Keithley representative or the factory to determine the correct course of action. Keithley Instruments maintains service facilities in the United States, West Germany, Great Britain, France, the Netherlands, Switzerland, and Austria. Information concerning the application, operation, or service of your instrument may be directed to the applications engineer at any of these locations. Check the inside front cover of this manual for addresses.

1.4 MANUAL ADDENDA

Information concerning improvements or changes to the instrument which occur after the printing of this manual will be found on an addendum sheet included with this manual. Be sure to review these changes before attempting to operate or service the instrument.

1.5 SAFTEY SYMBOLS AND TERMS

The following safety symbols and terms are used in this manual or found on the Model 195A:

The symbol ⚠ on the instrument indicates that the user should refer to the operating instructions in this manual.

The symbol ⚡ on the instrument indicates that a potential of 1000V or more may be present on the terminal(s). Standard safety practices should be observed when such dangerous voltages are encountered.

The **WARNING** heading in this manual explains dangers that could result in personal injury or death.

The **CAUTION** heading in this manual explains hazards that could damage the instrument.

1.6 SPECIFICATIONS

Detailed Model 195A specifications may be found immediately preceding this section of the manual.

1.7 UNPACKING AND INSPECTION

The Model 195A DMM was carefully inspected, both mechanically and electrically, before shipment. Upon receiving the Model 195A, carefully unpack all items from the shipping carton and check for any obvious signs of physical damage that might have occurred during shipment. Report any damage to the shipping agent immediately. Retain the original packing materials in case reshipment becomes necessary. The following items are included with every Model 195A order:

- Model 195A DMM
- Model 195A Instruction Manual
- Additional accessories as ordered.

If an additional instruction manual is required, order the manual package (Keithley Part Number 195A-901-00). The manual package includes an instruction manual and all pertinent addenda.

1.8 PREPARATION FOR USE

Once the instrument is unpacked, it must be connected to an appropriate power source as described below.

1.8.1 Line Power

The Model 195A is designed to operate from 105-125V or 210-250V 50/60HZ AC power sources. A special power transformer may be installed for 90-110V and 195-235V. The factory set value is marked on the instrument immediately above the line cord receptacle on the rear panel. The line cord receptacle is designed to mate with the supplied 3-wire power cord.

CAUTION

Do not attempt to operate the instrument on a supply voltage outside the indicated range, or damage to the instrument might occur.

NOTE

The NMRR specification is at 50 or 60Hz, $\pm .1\%$. For line frequencies out of this tolerance the filter mode can be used to improve measurement ability.

1.8.2 Line Voltage Selection

The operating voltage of the instrument is internally selectable. Refer to Section 7 Maintenance for information on setting the line voltage.

1.8.3 Line Frequency

The instrument will display the programmed line frequency upon power up. The line frequency may be set by using a front panel program as described in paragraph 3.5.5.

1.8.4 IEEE Primary Address

If the Model 195A is to be connected to the IEEE-488 bus, it must be programmed for the proper primary address. The factory programmed value is 16, but the address may be changed as described in Section 4.

1.8.5 Model 1950 Option Preparation

The Model 1950 option extends the capabilities of the Model 195A, allowing it to accurately measure AC voltage and AC and DC current. The Model 1950 will be factory installed if it was purchased with the Model 195A; however, the Model 1950 is easily installed in the field, as described in Section 7.

1.9 REPACKING FOR SHIPMENT

Before shipping the Model 195A, the instrument should be wrapped in plastic and carefully packed in its original carton.

If the Model 195A must be returned to Keithley Instruments for repair or calibration, include the following:

- Write ATTENTION REPAIR DEPARTMENT on the shipping label.
- Include the warranty status of the instrument.
- Complete the service form at the back of this manual and return it with the instrument.

1.10 USING THE MODEL 195A INSTRUCTION MANUAL

This manual contains information necessary for operating, programming, and servicing the Model 195A DMM and is divided into the following sections:

1. Section 2 contains basic DMM operating information, including front and rear panel layout and voltage, current and resistance measurement procedures.
2. Front panel programming information may be found in Section 3.
3. Information pertaining to the IEEE-488 bus, including primary address selection, programming, and bus connections, is contained in Section 4.
4. For the more technically oriented, information on performance verification, theory of operation, and maintenance and servicing information is contained in Sections 5 through 8.

1.11 ACCESSORIES

Accessories which can be used with the Model 195A are described in the following paragraphs.

1.11.1 Models 1019A and 1019S Rack Mounting Kits

The Model 1019A is a universal fixed rack mounting kit for the Model 195A. The Model 1019S is a slide type universal rack mounting kit.

1.11.2 Model 1600A High Voltage Probe

The Model 1600A extends the Model 195A measuring capabilities to 40kV. The Model 1600A has a 1000:1 division ratio; a one-volt indication on the Model 195A corresponds to a 1kV input voltage.

1.11.3 Model 1641 Kelvin Test Lead Set

The Model 1641 test leads are used when making 4-terminal resistance measurements. The leads are made up of two twin-lead cables 1.2m (48 inches) in length. Each cable is terminated by a twin banana plug on one end and a Kelvin spring-clip contact on the other end.

1.11.4 Model 1651 50-Ampere Shunt

The Model 1651 allows the Model 195A to make DC current measurements up to 50A. With the Model 1950 option installed, the shunt can be used with the Model 195A to make AC current measurements up to 50A as well. The Model 1651 consists of a 0.001Ω $\pm$1% 4-terminal resistance and operates with the Model 195A by developing a small measurable voltage; a 50A current will provide a reading of 50mV on the meter.

1.11.5 Model 1681 Clip-On Test Lead Set

The Model 1681 set contains two leads 1.2m (48 inches) in length. Each lead is terminated with a banana plug on one end and a spring-action clip-on probe on the other end.

1.11.6 Model 1682A RF Probe

The Model 1682A is an RF probe that extends the AC measuring capabilities of the Model 195A to include the 100kHz to 250MHz frequency range. Note that the probe provides a DC output, so the Model 1950 option is not necessary when making RF measurements. The Model 1682A provides a one-volt output for a one-volt RMS input when used with instruments having an input impedance of at least 10MΩ.

1.11.7 Model 1683 Universal Test Lead Kit

The Model 1683 kit consists of two test leads 1m (4in.) in length with 14 screw-in tips; four banana plugs, two spade lugs, four alligator clips, two probes and two phone tips.

1.11.8 Model 1685 Clamp-On AC Current Probe

The Model 1685 measures 50Hz and 60Hz AC currents up to 200A by clamping on to a single conductor, eliminating the need to open the circuit. The Model 1685 detects the current through a conductor by measuring the magnetic field around it. The output of the Model 1685 is 1V/A RMS.

1.11.9 Model 1691 General Purpose Test Lead Kit

The Model 1691 kit contains two 0.9m (36in.) test leads; each lead is terminated with a probe tip on one end and a banana plug on the other end.

1.11.10 Model 1950 AC Voltage; AC and DC Current Option

The Model 1950 option expands the capabilities of the Model 195A, allowing it to measure TRMS AC voltage between 1μV and 700V, TRMS AC current between 1nA and 2A, and DC current between 100pA and 2A. The Model 1950 plugs into the Model 195A for easy installation.

1.11.11 Model 1951 Input Adapter Box

The Model 1951 provides a means of interfacing probes terminated with a 4-wire instrumentation connector to the banana jacks on the instrument.

1.11.12 Model 7008 IEEE-488 Cable

The Model 7008 cables are useful for connecting the Model 195A to the IEEE-488 bus. The Model 7008-3 is 0.9m (3ft.) in length and has a standard IEEE-488 connector on each end. The Model 7008-6 is 1.8m (6ft.) in length.

1.11.13 Model 8691 Connector Kit

The Model 8691 Connector Kit contains a male 4-wire connector, a female 4-wire connector with attached coiled cable (mates with connector on Model 1951), and male and female 3-wire adapters.

1.11.14 Model 8693 General Purpose Immersion Probe

The Model 8693 is a general purpose probe designed for immersion in liquids as well as other general purpose applications. The Model 8693 measures between -220°C and +630°C and has a basic tolerance of ±0.3°C at 0°C.

1.11.15 Model 8695 Surface Probe

The Model 8695 probe is designed to measure the flat surfaces of solids in the range of -50°C to +260°C. The Model 8695 has a basic tolerance of ±0.3°C at 0°C.

1.11.16 Model 8696 Air/Gas Probe

The Model 8696 probe has an exposed junction within a protective shroud. The measurement range of the Model 8696 is between -50°C and +260°C; the probe has a basic tolerance of ±0.3°C at 0°C.

SECTION 2
BASIC DMM OPERATION

2.1 INTRODUCTION

Model 195A operation is divided into three general categories: basic bench operation, front panel program operation, and IEEE-488 operation. Basic bench operation, which is covered in this section, consists of using the Model 195A to perform basic voltage, current, resistance and temperature measurements. Front panel and IEEE programming can also be used to greatly enhance the capabilities of the instrument. These aspects are covered in detail in Section 3 and 4.

2.2 FRONT PANEL FAMILIARIZATION

The front panel layout of the Model 195A is shown in Figure 2-1. The front panel is generally divided into three sections: controls, terminals, and display and indicators. The following paragraphs describe the purpose of each of these items in detail.

2.2.1 Controls

All the front panel controls except POWER are momentary contact switches. Many controls include an annunciator light to indicate the selected mode. Most buttons have a secondary function for front panel progam operation as described in Section 3. The controls are color coded into functional groups for easier operation.

1. **POWER**—The Power switch controls the AC power to the instrument. Depressing and releasing the switch once turns the power on. Depressing and releasing the switch a second time turns the power off.

2. **FUNCTION**—The four FUNCTION pushbuttons control the type of measurement such as voltage, current, or resistance as follows:

NOTE

The Model 195A cannot measure AC voltage or AC or DC current without the Model 1950 option installed. Depressing the AMPS or AC buttons without this option installed will result in a "NoOP" message as described in paragraph 2.5.2.

VOLTS—The VOLTS button places the instrument in the DC volts or AC volts (with the Model 1950 option) operating modes. When the VOLTS button is depressed, the indicator above the button turns on, indicating the instrument is set for that mode.

OHMS—The OHMS button sets the Model 195A up to measure resistance. When this button is depressed, the indicator above the button turns on.

AMPS—With the Model 1950 option installed, the AMPS button is used to place the instrument in the DC or AC current mode. When the AMPS button is depressed, the indicator above it turns on.

AC—When the Model 1950 is installed, the AC button places the instrument in the AC voltage or current mode, depending on the selection performed with the VOLTS or AMPS buttons. Depressing the AC button once turns the AC indicator on; the instrument will measure an AC voltage or current in this mode. Depressing the AC button

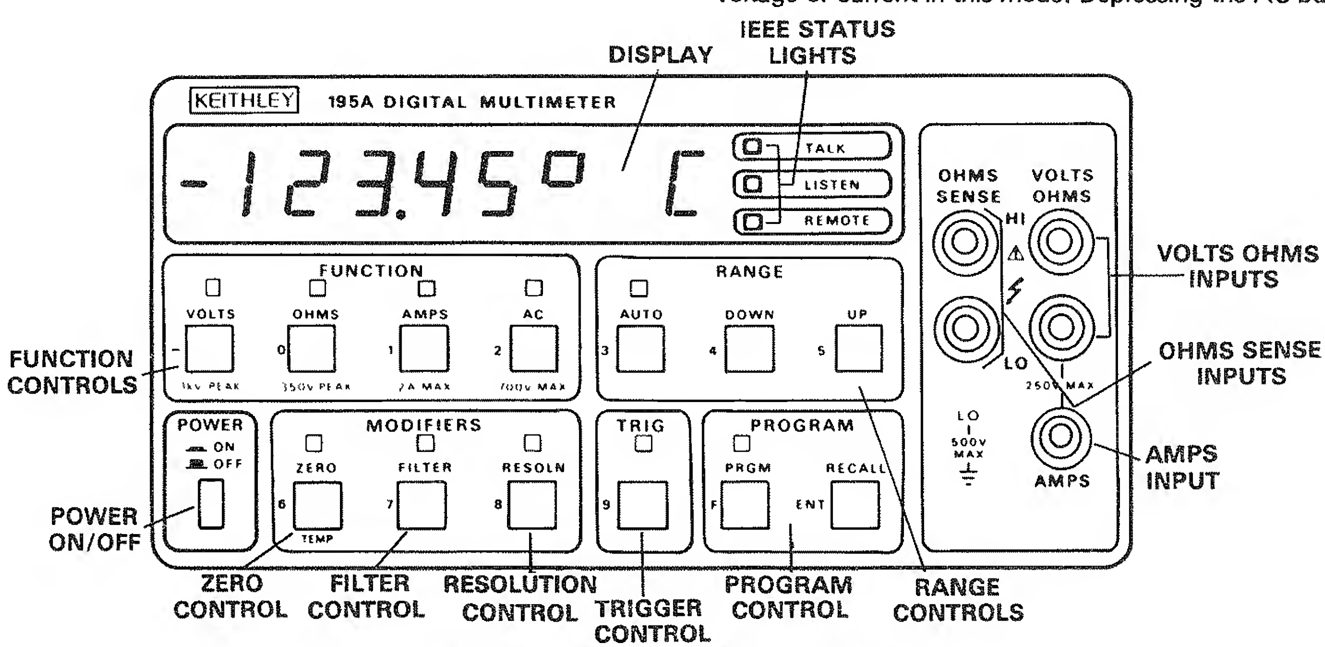


Figure 2-1. Model 195A Front Panel

a second time turns the AC indicator off; the instrument measures a DC voltage or current in this mode. Pressing AC when in the OHMS mode, places the instrument in the ACV mode.

3. **RANGE**—The RANGE buttons select the operating ranges of the instrument. The range in use can be determined from the display decimal point and exponent value as described in paragraph 2.6.2.

   AUTO—The AUTO button places the instrument in the autoranging mode. The instrument is operating in this mode when the AUTO indicator is on. When in the autoranging mode, the instrument automatically selects the best range to measure the applied input signal.

   DOWN—Each time the DOWN button is operated, the instrument moves downrange one increment.

   UP—Each time the UP button is operated, the instrument moves uprange one increment.

4. **MODIFIERS**—The MODIFIER buttons control the zero, filter and resolution modes of the instrument as described below.

   ZERO—The ZERO button controls a zero offset for baseline suppression. Depressing the ZERO button once enables zero as indicated by the ZERO light. Pressing ZERO a second time disables the zero mode.

   FILTER—The FILTER button controls the internal filter. Pressing this button once enables the filter; the indicator light will turn on to show that the filter is enabled. Depressing the FILTER button a second time disables the filter.

   RESOLN—The RESOLN button controls the display resolution. Each time this button is operated, the resolution changes to the alternate mode.

5. **TRIG**—The TRIG button is used to trigger readings when the instrument is in the front panel trigger mode. The TRIG button will be operational only if the TRIG indicator light is on. The instrument may be placed in the correct trigger mode through front panel Program 9 or through IEEE commands. One reading will be processed each time the TRIG button is operated.

6. **PROGRAM**—The PROGRAM buttons are used with the front panel programs as described in Section 3.

   PRGM—The PRGM button is used as the first step in entering front panel Program 0 through 9.

   RECALL/ENT—The RECALL/ENT button is used to enter and recall data associated with the front panel programs.

2.2.2 Terminals

The terminals are used to connect the Model 195A to the voltage, current, resistance or temperature to be measured. Note that the terminals are duplicated on the rear panel and that the rear panel INPUTS switch must be in the proper position for the front panel terminals to be active.

1. **VOLTS OHMS**—The VOLT OHMS terminals are used when making DC and AC (with the 1950) voltage measurements and resistance measurements. The HI terminal is considered to be positive with respect to the LO terminal when measuring DC voltage; the LO terminal is isolated from chassis ground.
2. **OHMS SENSE**—The OHMS SENSE terminals are used when making 4-terminal resistance measurements.
3. **AMPS**—The AMPS terminal is used in conjunction with the Model 1950 option to make DC and AC current measurements.

NOTE

Temperature measurements use the VOLTS OHMS and OHMS SENSE terminals.

2.2.3 Display and Indicators

The function of the display and indicators is described below.

1. **Display**—The display consists of a 5½ digit mantissa and a single digit exponent. Both the mantissa and exponent use a leading minus sign to indicate negative values. The sign on the exponent changes to + for zero or positive values. The range in use may be determined from the position of the decimal point and the exponent value as described in paragraph 2.6.2. The flashing rate of the decimal point indicates the conversion rate.

   NOTE

   The display will be in the 5½ digit mode upon power-up.

2. **IEEE Status Indicators**—The REMOTE, TALK and LISTEN indicators are used when programming the instrument over the IEEE-488 bus. Refer to Section 4 for complete IEEE programming information. These status lights are not operational during front panel instrument operation.

2.2.4 Tilt Bail

The tilt bail, which is located on the bottom cover of the instrument, is useful for elevating the front of the instrument to a convenient viewing height. To extend the bail, first rotate it 90° away from the bottom cover and push down on the legs to lock it into place. To retract the bail, pull the legs away from the bottom cover and then rotate the bail until it is flush with the bottom cover.

2.3 REAR PANEL FAMILIARIZATION

Figure 2-2 shows the rear panel layout of the Model 195A.

2.3.1 Connectors and Terminals

1. **AC Receptacle**—Power is applied through the supplied power cord to the 3-terminal AC receptacle. Note that the selected supply voltage is marked on the rear panel above the AC receptacle.
2. **IEEE-488 Connector**—This connector is used to connect the instrument to the IEEE-488 bus. IEEE interface functions are marked above the connector.
3. **VOLTS OHMS Terminals**—These terminals perform the same functions as the front panel VOLTS OHMS terminals.
4. **OHMS SENSE Terminals**—These terminals are used to make 4-terminal resistance measurements.
5. **AMPS**—The rear panel AMPS terminal performs the same function as the similar AMPS terminal on the front panel.
6. **EXTERNAL TRIGGER**—This BNC connector is used to apply pulses to trigger the Model 195A to take one or more readings, depending on the selected trigger mode.
7. **VOLTMETER COMPLETE**—This BNC output connector provides a pulse when the Model 195A has completed a reading; it is useful for triggering other instrumentation.

2.3.2 INPUTS Switch

The INPUTS switch selects either the front panel or rear panel terminals. When the switch button is at its inner most position, the front panel input terminals are selected. When the switch is out, the rear panel terminals are operational.

2.3.3 Fuses

The Model 195A has two fuse holders on the rear panel. For information on replacing these fuses, refer to Section 7. The purpose of the two rear panel fuses is described below.

1. **LINE FUSE**—This fuse provides protection for the AC power line input.
2. **AMPS FUSE**—This fuse protects the Model 1950 option from excessive current.

CAUTION
The AMPS FUSE only protects the instrument from excessive currents applied to the AMPS terminal; it does not protect the unit from excessive voltage applied to the other input terminals.

2.4 POWER-UP PROCEDURE

The basic procedure for powering up the Model 195A is described below.

1. Connect the female end of the power cord to the AC receptacle on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

CAUTION
Be sure the power line voltage agrees with the indicated value on the rear panel of the instrument. Failure to observe this warning

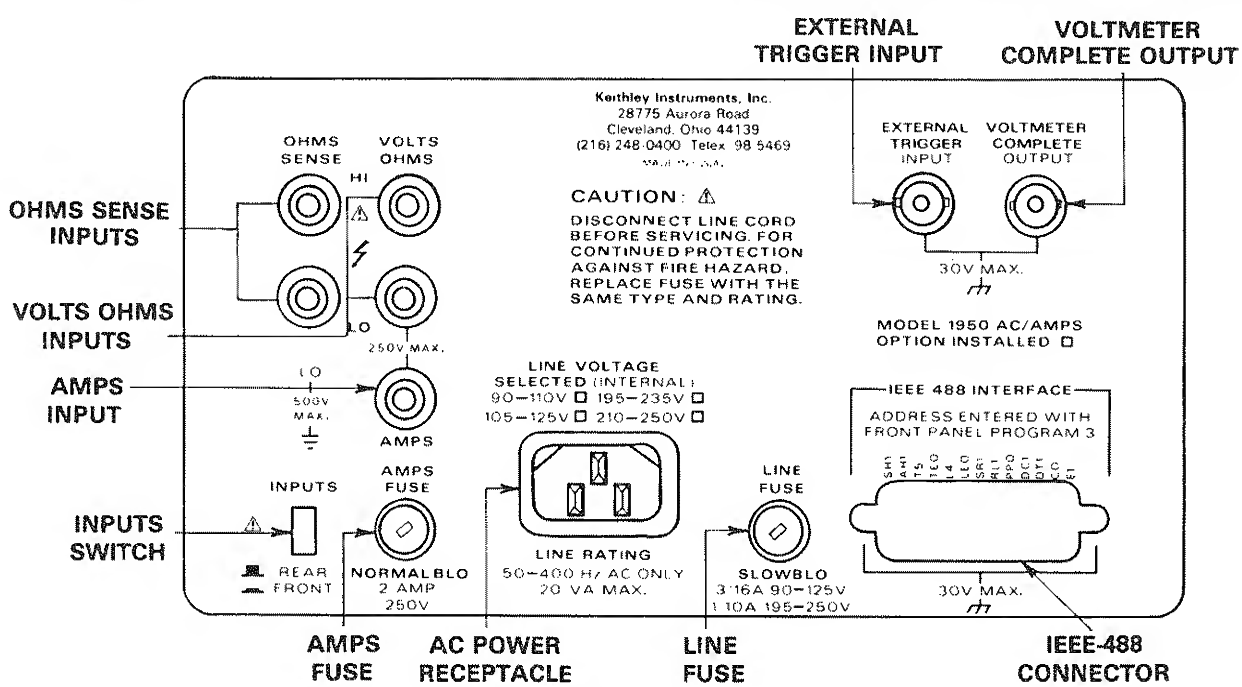


Figure 2-2. Model 195A Rear Panel

may result in instrument damage. If necessary, the power line voltage may be changed as described in Section 7.

WARNING

The Model 195A is equipped with a 3-wire power cord designed to be used with grounded outlets. When the proper connections are made, instrument chassis is connected to power line ground. Failure to use a properly grounded outlet may result in personal injury or death because of electric shock.

2. Turn on the power by depressing and releasing the POWER switch on the front panel.
3. The instrument will then begin operation by performing a display and indicator test for about two seconds. All mode and IEEE indicators will turn on and the display will appear as follows:

-1.8.8.8.8.8.8

To verify that all display segments are operating, compare the instrument's display during the test with the above figure.

4. Once the display test is completed, the instrument will perform NVRAM, ROM, and RAM. If all these tests are passed,the display will show the programmed line frequency and software revision level for about one second similar to the example below:

F60A0

F60 represents the line frequency, and A0 shows the software revision level.

NOTE

The programmed line frequency should be the same as the operating frequency. For information on programming the line frequency, refer to paragraph 3.5.5.

5. Following the line frequency and software revision level, the instrument will display the programmed IEEE primary address. For example, with the factory programmed value of 16, the display will show:

IE 16

6. Following these display messages, the instrument will go into the normal operating mode and begin displaying readings. The instrument will be in the following modes:

Function and Range: 1000VDC

Resolution: 5½ digits

Filter: Off

Zero: Off

Program Mode: Disabled

IEEE Status: Local

7. If any of the tests listed in step 4 fail, the instrument will display one of the error messages listed in Table 2-1. It is recommended that the power-up procedure be repeated several times to verify that a consistent error occurs; if so, a problem which must be rectified before operation, exists in the instrument. See Section 7 for troubleshooting information.

NOTE

If a NVRAM (Non-Volatile RAM) error occurs, instrument operation may be restored by depressing any front panel momentary contact button. However, instrument functions associated with NVRAM storage cannot be guaranteed. These include IEEE primary address, calibration accuracy, power line frequency, and Model 1950 option status.

2.5 DISPLAY MESSAGES

The Model 195A has two display messages associated with basic front panel operation. These messages indicate if an overrange input occurs and whether or not the Model 1950 option is installed. Note that the instrument has a number of additional display messages associated with front panel pro-

Table 2-1. Power Up Test Error Messages

Display	Message	Comments
unCAL	NVRAM Failure	Model 195A locks up, but operation may be restored by hitting any button. Instrument operation associated with NVRAM not guaranteed.
100000	ROM Error	Model 195A locks up.
1AAAAA	RAM Error	Model 195A locks up.

gramming (paragraph 3.4) and IEEE-488 programming (paragraph 4.11).

2.5.1 Overflow Indication

If an overrange input is applied to the Model 195A, the message below will appear on the display as long as the overflow condition persists:

OFLO

If the applied signal has a negative value, the leading minus sign will be present on the display as well.

2.5.2 No Option Message

The Model 1950 option must be present within the instrument before it can measure AC voltage or AC and DC current. If the front panel AC or AMPS button is depressed without the Model 1950 option installed, the following message will be displayed:

noOP

NOTE

When the Model 1950 option is first installed, option status must be enabled with NVRAM storage and the unit must be momentarily powered down, as described in paragraph 7.4.

2.6 CONTROL SELECTION

Selecting the various front panel operating modes is simply a matter of depressing the appropriate button as described in the following paragraphs.

2.6.1 Function

To measure voltage, current or resistance, the Model 195A must be set up for the proper measuring function with one of the four FUNCTION buttons.

1. To measure a DC voltage, depress the VOLTS button. If the AC indicator is on, depress the AC button to remove the instrument from the AC mode.
2. To measure resistance, depress the OHMS button.
3. To measure AC voltage (with the Model 1950 option), depress the VOLTS button. If the AC indicator is off, depress the AC button to place the instrument in the AC mode.
4. To measure DC current (with the Model 1950), depress the AMPS button. If the AC indicator is on, depress the AC indicator to remove the instrument from the AC mode.
5. To measure AC current, (with the 1950 option) depress the AMPS button. If the AC indicator is off, depress the AC button as well.

NOTE

The selected function affects the integration period and the samples averaged per reading. In DCV, DCA, and OHMS modes, the nominal integration period is 16.66ms (60Hz) or 20ms (50Hz), corresponding to the S2 rate mode. (See Table 4-13). In ACV and ACA modes, the integration period is 100ms, corresponding to the S6 rate mode.

2.6.2 Range

The voltage, current and resistance ranges of the Model 195A may be operated in either the AUTO range or manual range modes. When selecting a range manually, the instrument will move up or down range one increment each time the UP or DOWN button is operated. The range in use may be determined from the display by noting the position of the decimal point and the exponent value, as summarized in Table 2-2. The values in the table assume maximum display counts for the 5½ digit resolution mode.

The Model 195A ranges may be selected as follows:

1. To place the instrument in the autorange mode, depress

Table 2-2. Range Determination

DCV Range	Full Range Display	OHMS Range	Full Range Display	ACV Range*	Full Range Display	AC & DC Current Range*	Full Range Display
20mV	19.9999 −3	20 Ω	19.9999 +0	200mV	199.999 −3	20 μA**	19.9999 −6
200mV	199.999 −3	200 Ω	199.999 +0	2 V	1.9999 −3	200 μA	199.999 −6
2 V	1.99999 +0	2 kΩ	1.99999 +3	20 V	19.9999 +0	2mA	1.99999 −3
20 V	19.9999 +0	20 kΩ	19.9999 +3	200 V	199.999 +0	20mA	19.9999 −3
200 V	199.999 +0	200 kΩ	199.999 +3	700 V	700.00 +0	200mA	199.999 −3
1000 V	1000.00 +0	2MΩ	1.99999 +6			2 A	1.99999 +0
		20MΩ	19.9999 +6				

*Requires Model 1950 Option.
**20μA range not applicable to AC current measurements.
NOTE: Full range values shown for 5½ digit display mode; least significant digit of mantissa eliminated in 4½ digit mode.

the AUTO button. The AUTO light will turn on and the instrument will assume a range consistent with the applied signal.

2. To cancel the autorange mode, depress the AUTO button again; the AUTO light will go out and the instrument will remain on the present range.
3. Use the UP button to increment the range; the instrument will move uprange one increment each time the UP button is pressed. Pressing UP will also cancel the autorange mode.
4. Use the DOWN button to decrement the range; the Model 195A will move down range once each time the DOWN button is operated. Pressing DOWN will also cancel the autorange mode.

2.6.3 Using Zero

The zero mode serves as a means of baseline suppression allowing a stored offset value to be subtracted from subsequent readings. When the ZERO button is pressed, the instrument will store the baseline reading with the next triggered conversion; the ZERO LED will illuminate. All subsequent readings will represent the difference between the applied signal level and the stored baseline. For example, if 100mV is stored, a value of 100mV will be subtracted from the input voltage value.

A separate baseline can be stored for each of the five measuring functions: DCV; ACV; DCA; ACA; OHMS. The stored baseline can be as small as the resolution of the instrument will allow or as large as full range. Some examples are shown in the following.

Stored Baseline	Applied Signal	Displayed Value
+10.5000	+18.6000	+8.1000
+2.5560	+1.8000	−0.75600
-12.6000	+4.5000	+17.1000

NOTES:

1. Using zero reduces the dynamic range of the measurement. For example, if the stored baseline is +1.00000VDC with the instrument on the 2V range, an input voltage of -1.00000V or more will still overrange the instrument even though input voltages up to +1.99999 would normally be within the capabilities of the 2V range. If the instrument is in the autorange mode, it will move uprange if necessary.
2. Setting the range lower than the stored baseline will overrange the display; the instrument will display the "0FL0" message under these conditions.
3. Fine control over when the zero baseline is stored may be achieved by placing the instrument in the one-shot trigger mode (paragraph 2.7). Once the desired baseline is shown on the display, the instrument may be triggered to store the baseline with the appropriate trigger stimulus.
4. To store a new baseline value, the zero mode must disabled and then enabled once again. The new value will be stored with the first triggered conversion.
5. The zero mode should not be used to null the small offset in the AC mode.
6. The front panel zero should be performed within an hour of making measurements. This applies to a warmed up instrument under stable temperature conditions.

To use the zero mode, perform the following steps:

1. Disable the zero mode, if necessary, with the ZERO control.
2. Select a function and range consistent with the anticipated measurement.
3. Connect the instrument to the signal to be used as a baseline (See paragraph 2.8).

WARNING

The voltage present on the input terminal may be larger than the displayed value when using the zero mode. For example, if a 150VDC baseline is stored, an applied voltage of +175V will result in a displayed value of only +25V.

4. If desired, place the instrument in the front panel one-shot trigger mode by pressing PRGM and TRIG in sequence. The decimal point will stop flashing, indicating the instrument is waiting for a trigger to process the next reading.
5. Press the ZERO button. If the instrument is in the continuous mode, it will store the baseline with the first internally triggered conversion. If the instrument was placed in the one-shot mode, the baseline will have been stored when ZERO was pressed.
6. Repeat the above procedure for each desired measuring function. All readings made with the zero mode enabled will have the baseline subtracted from the applied signal value. The stored baseline will be retained until the zero mode is disabled or until instrument power is turned off.
7. To return the instrument to the normal display mode, disable the zero mode with the ZERO control.

2.6.4 Filtering

Basically, there are three different filter routines used in the Model 195A. These filters may be directly controlled through commands given over the IEEE-488 bus as described in Section 4. In addition, the filter in use is selected from the front panel as follows:

1. Enabling the filter with the FILTER button adds additional filtering. When the filter is enabled, the FILTER LED will be on. The FILTER light flashes until the final filtered reading is available.
2. The range in use affects which filter is selected; different filtering is used on the lowest (most sensitive) ranges.
3. The display resolution affects the amount of filtering: additional filtering is added in the 5½ digit mode.

Table 2-3 lists the filter in use for the various operating combinations. When the FILTER light is on, Filter 1 is selected.

NOTES:

1. Filtering cannot be totally disabled with the front panel FILTER button. It can, however, be disabled with a command given over the IEEE bus as described in Section 4.
2. Adding more filtering, slows down the response time of the instrument to sudden changes in input signal. For example, instrument response is slower with the front panel filter enabled than when it is disabled.

Table 2-3. Filter Modes

Filter Mode	Conditions	Reading Samples Averaged
Filter 1	FILTER ON	64
Filter 2	5½ Digits, FILTER Off	32
Filter 3	20mV, 200mVDC; 20Ω, 200Ω, 20MΩ all DCA	8

2.6.5 Display Resolution

The display resolution of the Model 195A may be set to either 4½ or 5½ digits with the front panel RESOLN button. To place the instrument in the 4½ digit mode, press RESOLN. To return to 5½ digits, press RESOLN again.

2.6.6 Input Terminal Selection

The Model 195A has two complete sets of input terminals. The front panel set of terminals is convenient for making connections when the instrument is operated on a bench. The rear set of terminals is useful for making connections when the Model 195A is mounted in a rack. To select the appropriate set of terminals, use the rear panel INPUTS switch as follows:

1. To use the rear panel terminals, depress and release the switch so that the switch button is at its outer most position.
2. To change to the front panel terminals, depress and release the INPUTS switch a second time so that the button is at its inner most position.

2.7 TRIGGERING

The Model 195A may be triggered to take readings in three ways:

1. With the front panel TRIG button when in the appropriate trigger mode.
2. Through a trigger pulse applied to the rear panel EXTERNAL TRIGGER input connector when in an appropriate trigger mode.
3. With commands given over the IEEE bus as described in Section 4.

This section covers front panel and external triggering in detail. Also, included is a description of the Model 195A trigger output pulse which can be used to trigger other instruments.

2.7.1 Front Panel Triggering

Front panel triggering is done with the TRIG control. To use front panel triggering perform the following steps:

1. Enter the one-shot mode by depressing PRGM and TRIG (9) in sequence. The TRIG light will turn on and the decimal point on the display will cease flashing, indicating the instrument is in the one-shot trigger mode. While in this mode, no new readings are processed until a trigger stimulus is applied.
2. To trigger a single reading, depress and release the TRIG button once. The display decimal point will flash once and the display will be updated with the most recent reading. The TRIG light flashes until the final, filtered reading is displayed.
3. To continue processing readings, depress the TRIG button. One reading will be processed each time the TRIG button is operated.
4. To remove the instrument from the one-shot trigger mode, depress the PRGM and TRIG (9) buttons in sequence. The TRIG light will go out and the display decimal point will flash at the conversion rate.

NOTES:

1. The PRGM, TRIG button sequence actually enters front panel Program 9. The control sequence for this and other front panel programs is described in more detail in Section 3.
2. Each time the PRGM, TRIG button sequence is performed, the instrument toggles between the continuous and one-shot modes. This control sequence also affects IEEE bus triggering which is described in Section 4.
3. The front panel TRIG button can be used to control the 100 reading data buffer. Each time the button is operated, one reading is stored. These aspects are covered in Sections 3 and 4.
4. The Model 195A must be in the correct trigger mode, as described in Section 4, before it will respond to a front panel trigger stimulus. (The instrument is placed in the front panel mode upon power-up.)
5. The display will continue to be updated during the filter processing period following the trigger stimulus; however, the final filtered reading is not displayed until the TRIG light turns back on.
6. Pressing any other front panel button will also trigger an A/D conversion.

2.7.2 External Trigger

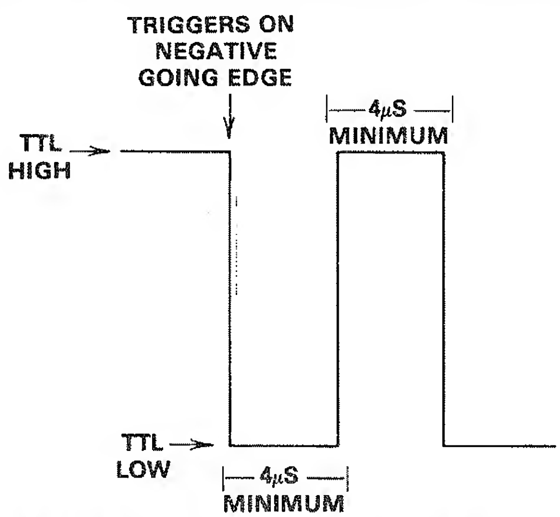
External trigger operates much like front panel triggering except for the trigger stimulus itself. In this case, the trigger is applied to the rear panel BNC EXTERNAL TRIGGER connector (see Figure 2-2). The input trigger pulse must conform to TTL logic levels. Figure 2-3 shows the specifications for the input trigger pulse. To use external triggering, proceed as follows:

1. Connect the external trigger source to the rear panel BNC EXTERNAL TRIGGER connector. The shield (outer) part of the connector is connected to digital common.

CAUTION
Do not exceed 30V between common and chassis ground or damage to the instrument may occur.

2. Place the instrument in the one-shot trigger mode by depressing the PRGM and TRIG buttons in sequence. The TRIG light will turn on and the decimal point in the display will stop flashing. The Model 195A will cease to process readings while it is waiting for a trigger.
3. To trigger the instrument, apply a pulse to the EXTERNAL TRIGGER input. The instrument will process and display one reading for each input trigger pulse. The TRIG light flashes until the final, filtered reading is displayed.
4. To return the instrument to the continuous trigger mode, press PRGM and TRIG in sequence. The TRIG light will go out and the display decimal point will flash at the conversion rate.

NOTES:
1. External triggering can be used to control the fill rate of the 100 reading buffer. One reading will be stored each time an external trigger pulse is received. See Sections 3 and 4.
2. The Model 195A must be in appropriate trigger mode to respond to external triggering as described in Section 4.



CAUTION: Do not exceed normal TTL level.

Figure 2-3. External Trigger Input Pulse Specifications

2.7.3 Voltmeter Complete

The Model 195A has an available trigger pulse that can be used to trigger other instrumentation. A single pulse, conforming to the specifications in Figure 2-4, will appear at the VOLTMETER COMPLETE output on the rear panel each time the Model 195A completes a conversion. To use the VOLTMETER COMPLETE output, proceed as follows:

1. Connect the Model 195A to the instrument to be triggered with a suitable shielded cable. Use a standard BNC connector to make the connection to the Model 195A.

CAUTION
Do not exceed 30V between the VOLTMETER COMPLETE common (outer ring) and chassis ground or instrument damage may occur.

2. Select the desired function, range, trigger mode, and other operating parameters, as desired.
3. In the continuous trigger modes, the instrument will output pulses at the conversion rate; each pulse will occur after the Model 195A completes a conversion.
4. In one of the one-shot trigger modes, the Model 195A will output a pulse once each time it is triggered after it completes its reading.

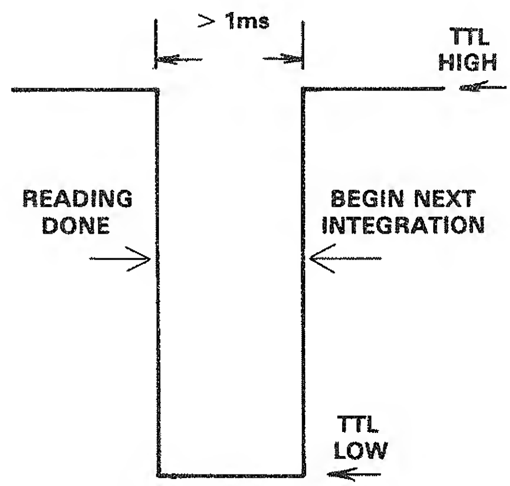


Figure 2-4. Voltmeter Complete Output Pulse Specifications

2.7.4 Triggering Example

As an example of using external input and output triggering, assume the Model 195A is to be used in conjunction with a Keithley Model 230 Programmable Voltage Source. The Model 230 can be programmed to output up to 100 voltage levels for given time periods. As each output voltage is applied, the Model 230 triggers the Model 195A to take a reading. When the Model 195A completes its reading, it triggers the Model 230 to output the next programmed voltage value, and the sequence repeats automatically until all the readings have been taken. The readings can be stored in the Model 195A data buffer for recall after the test is completed.

To use the Model 230 with the Model 195A, perform the following steps:

1. Connect the Model 195A to the Model 230 as shown in Figure 2-5. Use suitable shielded cables with BNC connectors. The Model 195A VOLTMETER COMPLETE OUTPUT should be connected to the Model 230 EXTERNAL TRIGGER INPUT. The Model 195A EXTERNAL TRIGGER INPUT should be connected to the Model 230 EXTERNAL TRIGGER OUTPUT.
2. Place both instruments in the external trigger mode.
3. Connect both the Model 195A and the Model 230 to the circuit under test. (See paragraph 2.8).
4. Program the Model 230 with the desired output voltages and dwell times. Set the Model 195A to the appropriate function and range. If desired, enable the data buffer for reading storage (See Section 3).
5. Trigger the Model 195A with the front panel TRIG button. After the Model 195A has taken the reading, it will trigger the Model 230 to advance to the next programmed value. Each instrument will trigger the other until all readings have been taken.

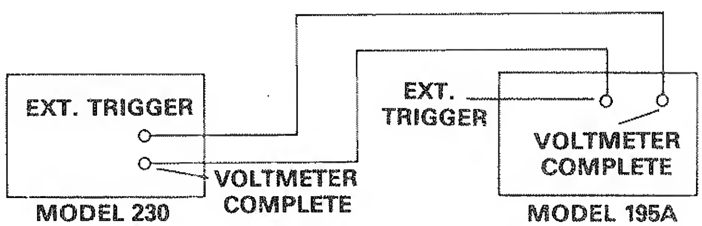


Figure 2-5. External Trigger Connections

2.8 BASIC MEASUREMENTS

Basic measurement techniques for using the Model 195A to measure DC volts, resistance, temperature, and AC and DC current are covered in the following paragraphs.

NOTE
AC voltage, and AC and DC current measurements can be made only if the Model 1950 option is installed.

Voltage measurements are made by connecting the source between the HI and LO VOLTS OHMS measurements. Two-terminal resistance measurements are made by connecting the resistance between the two VOLTS OHMS terminals. Four-terminal resistance measurements require the use of both the VOLTS OHMS terminals and the OHMS SENSE terminals. Both AC and DC current measurements are made by connecting the source to the AMPS and VOLTS OHMS LO terminals.

WARNING
Hazardous voltages may be present on the LO terminals. Any voltage applied to the VOLTS OHMS LO terminal will also be present on the OHMS SENSE LO terminal.

The LO terminals on the Model 195A are designed to float from chassis ground to avoid ground loop problems. Chassis ground is connected to power line through the ground wire in the power cord when used with a properly grounded three-wire outlet.

WARNING
The maximum voltage between the VOLTS OHMS LO terminal and chassis ground is 500V. Destruction of insulation, which could present a shock hazard, may occur if the 500V maximum is exceeded. The maximum voltage between the AMPS terminal and VOLTS OHMS LO terminal is 250V.

CAUTION
Do not exceed the maximum input limits shown in Table 2-4.

Table 2-4. Maximum Input Values

Function	Maximum Input
DC VOLTS	1000VDC or peak AC
AC VOLTS	700V RMS, 1000V peak, 10^7•Hz
DC AMPS	2A, 250V (fuse protected)
AC AMPS	2A, 250V RMS, 350V peak (fuse protected)
OHMS	360V peak or 250V RMS

2.8.1 DC Voltage Measurements

The Model 195A can make DC voltage measurements between 100nV and 1000V. The nominal bench reading rate is seven readings per second. The basic procedure for making DC voltage measurements is as follows:

1. Turn on the power with the front panel POWER switch. If the instrument is within 0°C to 50°C, it is useable immediately, but allow a one hour warm-up period for rated accuracy.
2. Connect the test leads to the front or rear panel VOLTS OHMS HI and LO terminals. Make sure the rear panel INPUTS switch is in the correct position. These binding posts accept banana plugs, spade lugs, or bare wires for easy connections. Use low-thermal cables and connections for the 20mV and 200mV ranges to minimize the effects of thermal EMFs.
3. Select the DC volts function by depressing the VOLTS button. If the AC indicator is on, cancel AC mode by depressing the AC button. Note that the instrument will be in the DC mode upon power-up.
4. Select a range consistent with the expected voltage. For automatic range selection, use the autorange mode.
5. Set the display resolution as desired with the RESOLN button.
6. If the instrument is to be used on the 20mV or 200mV ranges, the zero should be enabled to compensate for ther-

mal offsets which could upset accuracy. To zero the instrument, perform the following steps:

A. Select the 20mV range.

B. With the test leads disconnected from the source, short them together.

C. Press the ZERO button.

D. Select the range, as desired.

7. Connect the test leads to the source as shown in Figure 2-6.

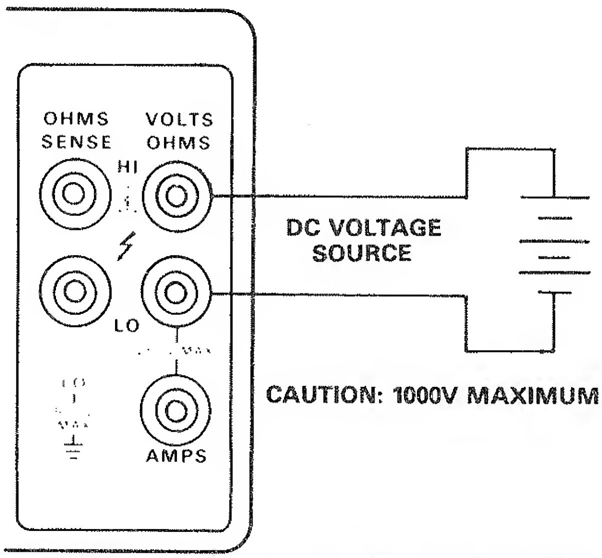


Figure 2-6. DC Voltmeter Measurements (Front Panel Connections Shown)

CAUTION
Do not exceed 1000V between HI and LO VOLTS OHMS terminals.

If the positive source terminal is connected to the HI terminal of the instrument, the display will show a positive value. If the negative source terminal is connected to the HI terminal, the display will show a negative value.

8. Observe the display; if the "OFLO" message is shown, move the instrument up range until a normal reading is shown. Always use the lowest possible range for the best accuracy. If the reading is unstable, use the FILTER control.

9. Take the reading from the display. The reading may be interpreted by taking into account both the position of the decimal point and the exponent (see Table 2-2). For example, assume the display shows the following:

-12.456+0

The reading is -12.456VDC.

2.8.2 Resistance Measurements

The Model 195A can make resistance measurements between 100Ω and 20MΩ. The nominal bench reading rate for all ranges except the 20MΩ range is four readings per second. The nominal rate for the 20MΩ range is two readings per second. The Model 195A provides automatic selection of 2-terminal or 4-terminal resistance measurements. For best results on the 20Ω and 200Ω ranges, it is recommended that 4-terminal measurements be made to eliminate errors caused by the voltage drop across the test leads that occurs when 2-terminal measurements are made. To make resistance measurements, proceed as follows:

1. Turn on the power with the front panel POWER switch. For rated accuracy, allow a one hour warm-up period.
2. Connect the test leads to the front or rear panel VOLTS OHMS terminals. If 4-wire measurements are to be made, connect an additional set of leads to the OHMS SENSE terminals. Make sure the rear panel INPUTS switch is in the correct position.

NOTE
The Model 1641 Kelvin test lead kit is ideal for low resistance 4-terminal measurements.

3. Press the OHMS button and select a range consistent with the expected resistance. If desired, use autoranging. Set the display resolution as desired.
4. If readings are to be made on the 20Ω or 200Ω ranges, use the zero mode to obtain rated accuracy. To zero the instrument for resistance measurements, proceed as follows: short the test leads together after disconnecting them from the measured circuit; of 4-wire measurements are to be made, short all four leads, then press the ZERO button.
5. For 2-wire measurements, connect the instrument to the measured resistance as shown in Figure 2-7. For 4-wire measurements, use the connections shown in Figure 2-8.

CAUTION
The maximum input voltage between the VOLTS OHMS HI and LO terminals is 250VDC or RMS, 360V peak. Do not exceed these values, or instrument damage may occur.

Table 2-5 shows the voltage and current output values for the various resistance ranges. Note that the HI terminal is negative with respect to the LO terminal when the instrument is the OHMS mode.

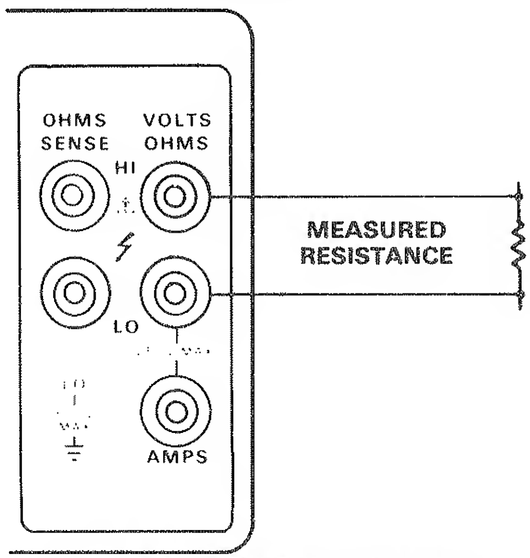
Table 2-6 shows the maximum allowable test lead resistance to contribute ≤ 1 count of additional error when making 4-wire resistance measurements.

6. Take the reading directly from the display, using the information in Table 2-2. (If the display is unstable, use the

FILTER control). For example, assume the following value is displayed:

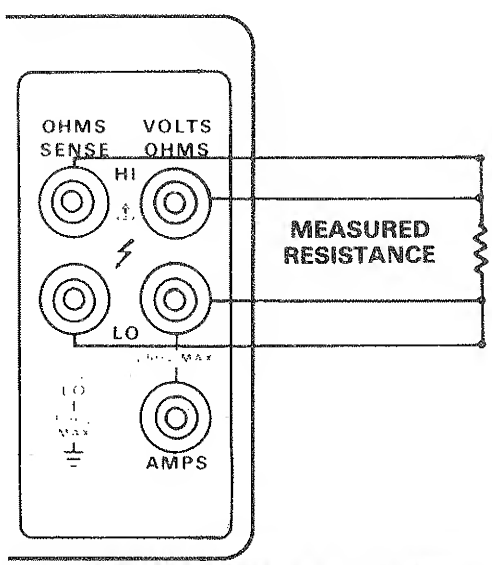
68423+3

The resistance value is 68.423kΩ.



CAUTION: MAXIMUM VOLTAGE 360V PEAK, 250V RMS

Figure 2-7. Two-Terminal Resistance Measurement (Front Panel Connections Shown)



CAUTION: MAXIMUM VOLTAGE 360V PEAK 250V RMS

Figure 2-8. Four-Terminal Resistance Measurements (Front Panel Connections Shown)

Table 2-5. Resistance Range Output Values

Range	I Short	V Open
20 Ω	– 2mA	–2V
200 Ω	– 2mA	–2V
2 kΩ	– 2mA	–2V
20 kΩ	– 20 μA	–2V
200 kΩ	– 20 μA	–2V
2MΩ	–0.2 μA	–2V
20MΩ	–0.2 μA	–2V

2.8.3 Temperature Measurements

The Model 195A is capable of temperature measurements in the range of -220°C and +630°C and between -360°F and +1100°F. Using the instrument to measure temperature is simply a matter of connecting a suitable probe and entering front panel Program 6, as described in Section 3.

Probe Connection (Using the Model 1951)—To connect a temperature probe to the instrument, proceed as follows:

WARNING
To avoid possible shock hazards, disconnect all test leads from the Model 195A before connecting the adapter box or temperature probe.

1. Connect the Model 1951 Input Adapter Box to the VOLTS OHMS and OHMS SENSE terminals on the front or rear panel of the Model 195A as desired. The input box is designed with suitable banana plugs designed to connect with the Model 195A banana jacks and includes a 4-wire connector. The box is designed to connect only one way.
2. Check to see that the rear panel INPUTS switch is in the correct position.
3. Connect the temperature probe to the jack on the front of the adapter. If desired, a probe may be wired using the connections shown in Figure 2-9.

NOTE
As shipped, the Model 195A is calibrated to use platinum probes conforming to the DIN 43 760 standard (alph = 0.00385). Instrument calibration may be changed for other standards as described in Section 5.

Probe Connection (Directly to the Model 195A)-4-wire probes and sensors can be used without the Model 1951 Input Adapter Box by connecting them directly to the input of the Model 195A as shown in Figure 2-10(a).

WARNING
Remove all test leads from the Model 195A before connecting the temperature probe.

REAR VIEW

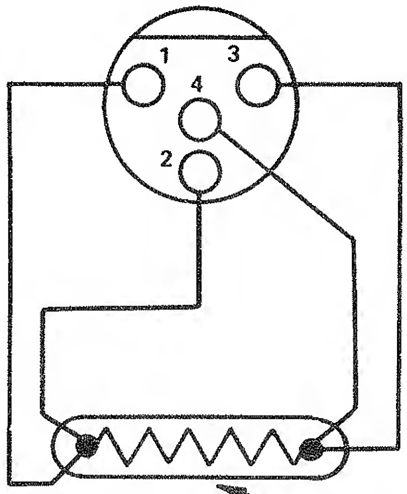


Figure 2-9. Model 195A Probe Wiring

3-Wire Sensor Operation—As supplied, the Model 195A is designed for operation with 4-wire probes, such as the Model 8693 probe. However, the unit may be used with an appropriate 3-wire platinum RTD probe by using the connections shown in Figure 2-10(b). Before using a 3-wire probe, the instrument must be properly programmed as described in the calibration procedure in Section 7 of this manual.

WARNING
To avoid possible shock hazards, disconnect all test leads from the Model 195A before connecting the temperature probe.

NOTE
Model 195A temperature accuracy figures given in the specifications are based on 4-wire operation.

Calibration Standards—As shipped, the Model 195A is calibrated for use with probes conforming to the DIN 43 760 standard. Another popular temperature standard is the IPTS-68 standard, which uses different calibration parameters, as summarized in Table 2-7. Note that it is imperative that the instrument be calibrated for the standard for which the probe is designed, or inaccurate temperature readings will result. Instrument calibration is covered in detail in Section 7.

Table 2-6. Four-Wire Maximum Allowable Test Lead Resistance.

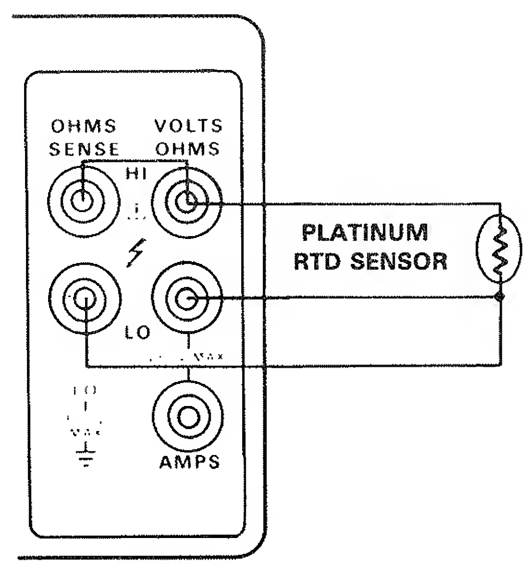
Range	In Maximum Test Lead Resistance for ≤1 Count Error	
	4½ Digit Resolution	5½ Digit Resolution
20 Ω	7 Ω	2 Ω
200 Ω	22 Ω	7 Ω
2 kΩ	70 Ω	22 Ω
20 kΩ	220 Ω	70 Ω
200 kΩ	700 Ω	220 Ω
2MΩ	2.2kΩ	700 Ω
20MΩ	7kΩ	2.2kΩ

NOTE: Values are for each test lead and assume that each lead has the same resistance.

Table 2-7. Calibration Standards

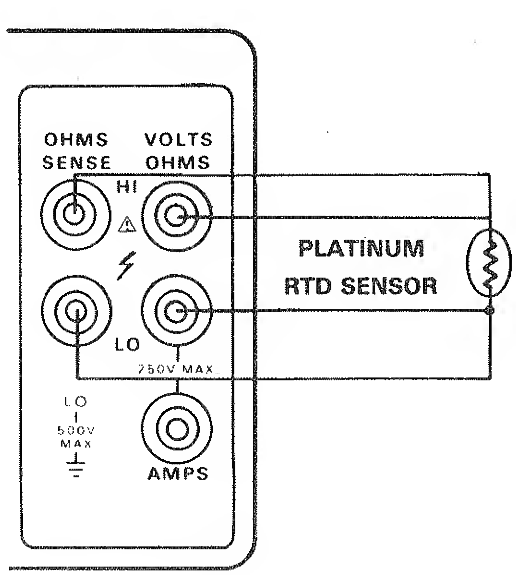
Parameter	DIN 43 760 Standard	IPTS-68 Standard
R_o (Probe resistance at 0°C)	100.00Ω	100.00Ω
Alpha	0.00385	0.00392
Delta	1.502	1.49633
A4, C4	*	*

*Not directly programmable; automatically programmed by selection of DIN 43 760 or IPTS-68 during calibration.



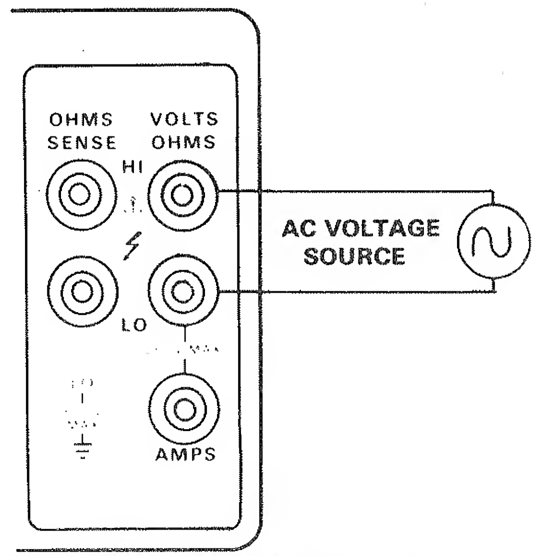
(A) 3-WIRE

Figure 2-10. Sensor Connections



(B) 4-WIRE

Figure 2-10. Sensor Connections (Cont.)



INPUT IMPEDANCE: 2MΩ SHUNTED BY LESS THAN 75pF

Figure 2-11. AC Voltage Measurement (Front Panel Connections Shown)

2.8.4 AC Voltage Measurements

With the Model 1950 option installed, the Model 195A can make TRMS AC voltage measurements between 1V and 700V. To make AC voltage measurements, proceed as follows:

1. Turn on the power with the front panel POWER switch. Allow a one hour warm-up period for rated accuracy.
2. Connect the test leads to the front or rear panel VOLTS OHMS terminals. Make sure the rear panel INPUTS switch is in the correct position.
3. Depress the VOLTS button; enable the AC mode with the AC button. The instrument is in the AC mode when the AC indicator is on.

NOTE
A "NO OP" message will appear on the display if the AC button is pressed without the Model 1950 option installed.

4. Select the display resolution and turn on the filter, if desired.
5. Select a range appropriate for the measured voltage. If desired, use the autorange mode.
6. Connect the instrument to the source as shown in Figure 2-10.

CAUTION
Do not exceed 700VRMS, 1000V peak between the HI and LO terminals or the instrument might be damaged.

NOTE
Do not use ZERO to null any offset in the AC mode.

7. If the display shows an overflow, move the instrument uprange.
8. Make the reading from the display; include the position of the decimal point and the exponent to interpret the reading. For example, assume the display reads as follows:

195.000-3

The source value is 195.000mV.

2.8.5 DC Current Measurements

With the Model 1950 option installed, the Model 195A is capable of DC current measurements between 100pA and 2A. Proceed as follows:

1. Turn on the power with the front panel POWER switch. For rated accuracy, allow a one hour warm-up period.
2. Connect the test leads to the front or rear panel AMPS and VOLTS OHMS LO terminal. Make sure the INPUTS switch is in the correct position.
3. Depress the AMPS button; if the AC indicator is on, depress the AC button to place the instrument in the DC mode.

NOTE
Pressing AMPS or AC without the Model 1950 option installed will result in a "NO OP" message.

4. Select an appropriate range for the expected current; alternately, use the autorange mode, if desired.
5. Select appropriate resolution, and filter modes.
6. Connect the Model 195A to the current source as shown in Figure 2-12.

CAUTION
Do not exceed the 2A current limitation or the amps fuse will blow.

If an overrange indication is shown, move the instrument uprange until a normal reading can be observed. Use the lowest possible range for the best accuracy.

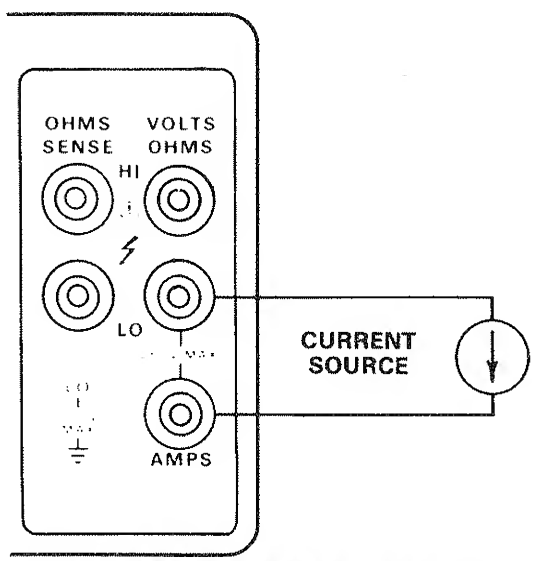
7. Make the reading from the display, taking into account the position of the decimal point and the exponent value. For example, assume the display reads as follows:

-8.42 10-6

The reading is -8.421μA

2.8.6 AC Current Measurements

With the Model 1950 option installed, the Model 195A is capable of making TRMS AC current measurements between 1nA and 2A. To make AC current measurements, proceed as follows:



CAUTION: MAXIMUM INPUT 2A, 250V

Figure 2-12. DC and AC Current Measurement (Front Panel Connections Shown)

1. Turn on the power with the front panel POWER switch. Allow a one hour warm-up period for rated accuracy.
2. Connect the test leads to the front or rear panel AMPS and VOLTS OHMS LO terminals. Make certain the rear panel INPUTS switch is in the correct position.
3. Depress the AMPS button; if the AC indicator is off, depress the AC button to place the instrument in the AC mode.

NOTE
Pressing AMPS or AC without the Model 1950 option installed will result in a "NO OP" message on the display.

4. Select a range suitable to measure the expected current, or use the autorange mode, if desired.
5. Select appropriate resolution, and filter modes.
6. Connect the Model 195A to the current source as shown in Figure 2-12.

CAUTION
Do not exceed the 2A limitation or the amps fuse will blow.

7. If an overrange indication is shown, move the instrument range until a normal reading is observed. Use the lowest possible range for best accuracy.
8. Make the reading from the display by determining the decimal point position and exponent value. For example, assume the display reads as follows:

2.4560 - 3

The reading is 2.456mA.

2.9 TRMS CONSIDERATIONS

Most DMMs actually measure the average value of an input waveform but are calibrated to read its RMS equivalent. This poses no problems as long as the waveform being measured is a pure, low-distortion sine wave. For complex, non-sinusoidal waveforms, however, measurements made with an averaging type meter can be grossly inaccurate. The Model 195A, because of its TRMS (True Root Mean Square) measuring capabilities (with the Model 1950 option), provides accurate AC measurements for a wide variety of AC input waveforms.

2.9.1 TRMS Measurement Comparison

The RMS value of a pure sine wave is equal to 0.707 times its peak value. The average value of such a waveform is 0.637 times the peak value. Thus, for an average-responding meter, a correction factor must be applied. This correction factor, F, can be found by dividing the RMS value by the average value as follows:

$$F = \frac{0.707}{0.637} = 1.11$$

By applying this correction factor to an averaged reading, a typical meter can be calibrated to give the RMS equivalent. This works fine as long as the waveform is a pure sine wave, but the ratios between the RMS and average values of different waveforms is far from constant, and can vary considerably.

Table 2-8 shows a comparison of three common types of waveforms. For reference, the first waveform is an ordinary sine wave with a peak amplitude of 10V. The average value of this voltage is 6.37V, while its RMS value is 7.07V. By applying the 1.11 correction factor to the average reading, it can be seen that both meters will give the same reading, resulting in no error in the average-type meter reading.

The situation changes with the half-wave rectified sine wave. As before, the peak value of the waveform is 10V, but the average value drops to 3.18V. The RMS value of this waveform is 5V, but the average responding meter will give a reading of 3.53V (3.18 × 1.11), creating an error of almost 11%.

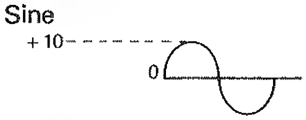
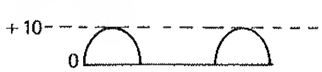
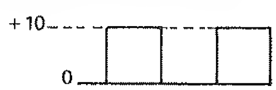
A similar situation exists for the rectified square wave, which has an average value of 5V and an RMS value of 7.07V. Here, the average responding meter gives a reading of 5.55V (5 × 1.11), while the Model 195A gives a TRMS reading of 5V.

2.9.2 Crest Factor

The crest factor of a waveform is the ratio of its peak value to its RMS value. Thus, the crest factor specifies the dynamic range of a TRMS instrument. For sinusoidal waveforms, the crest factor is 1.414. For a symmetrical square wave, the crest factory is unity.

The crest factor of other waveforms will, of course, depend on the waveform in question because the ratio of peak to RMS value will vary. For example, the crest factor of a rectangular pulse is related to its duty cycle; as the duty cycle decreases, the crest factor increases. The Model 195A has a crest factor of 3, which means the instrument will give accurate TRMS measurements of rectangular waveforms with duty cycles as low as 10%.

Table 2-8. Comparison of Average and TRMS Meter Readings

Waveform	Peak Value	Rectified Average Value	RMS Value	Average Responding Meter Reading	AC Coupled TRMS Meter Reading	Averaging Meter Percent Error
Sine 	10V	6.37V	7.07V	7.07V	7.07V	0%
Half-Wave Sine 	10V	3.18V	3.86V	3.53V	3.86V	8.5%
Rectified Square Wave 	10V	5V	5V	5.55V	5V	11%

SECTION 3
FRONT PANEL PROGRAMS

3.1 INTRODUCTION

This section contains information and instructions necessary for operating the 10 front panel programs of the Model 195A. The programs are entered by depressing the front panel PRGM button followed by the desired program number (0-9). Some of the programs require numeric constants, which must be entered from the front panel. Others will display appropriate messages. Model 195A programs are summarized in Table 3-1.

3.2 PROGRAMMING CONTROLS

Most of the front panel controls serve a dual purpose. The FUCNTION, RANGE, MODIFIER, and TRIG buttons are numbered in sequence. Figure 3-1 shows the controls used with the front panel programs; these buttons are used as follows:

1. PRGM is used to place the instrument in the program mode.
2. 0 through 9 are used to select one of the ten programs as well as enter constants in those programs that require them. Minus (-) is used as a modifier.
3. RECALL/ENT is used to enter and recall numeric constants associated with the various programs.

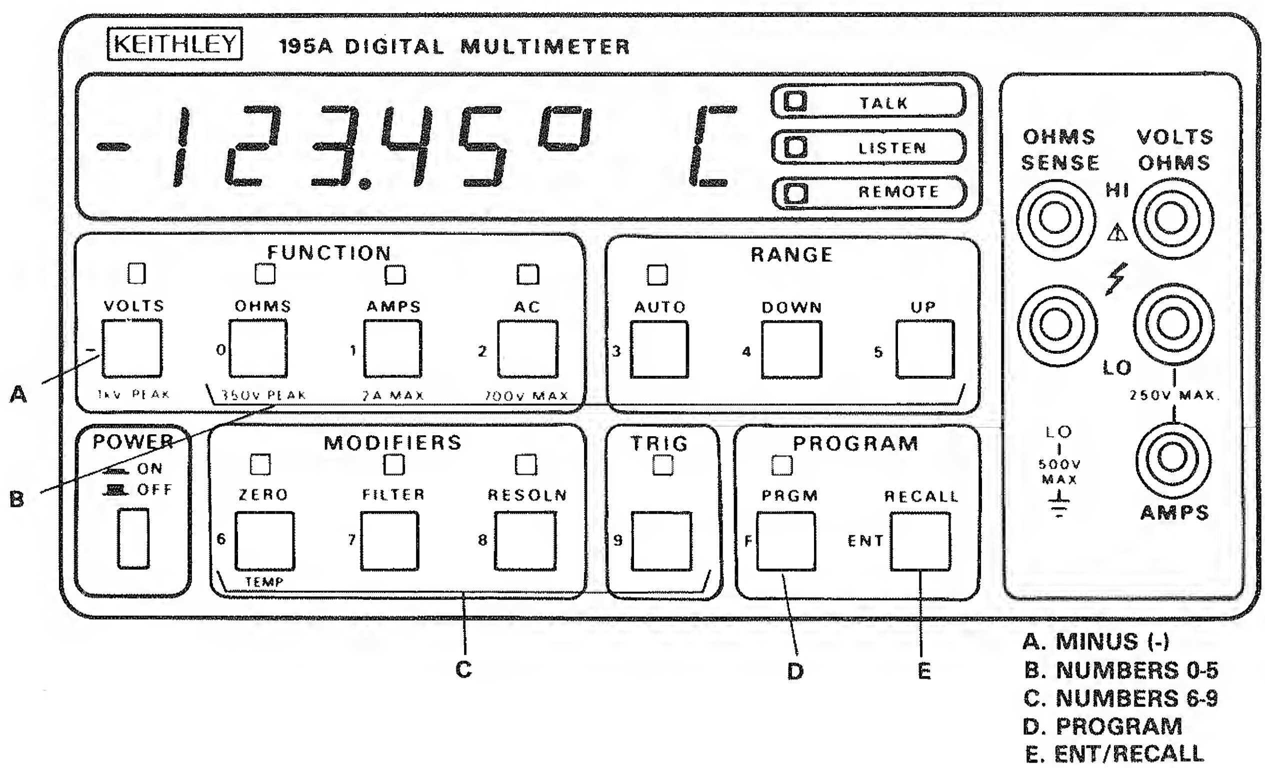


Figure 3-1. Front Panel Program Controls

Table 3-1. Front Panel Program Summary

Program	Description
0, Clear	Cancel program mode.
1, NV Storage	Non-volatile storage of parameters stored in Program 3, 4, 5, 6 and 8.
2, Multiplex	Defeats input amplifier multiplexer.
3, IEEE Address-Talk-Only	Enter IEEE primary address; control talk only mode and format.
4, Line Frequency	Program 50Hz or 60Hz line frequency.
5, Digital Calibration	Allows digital calibration of the Model 195A.
6, Temperature	Allows °C and °F Temperature measurements.
7, Data Logger	Enables data storage in 100 point buffer.
8, Diagnostics	Used for troubleshooting; performs ROM, RAM, display tests; programs Model 1950 status.
9, Trigger	Toggles between one-shot and continuous trigger modes.

3.3 FRONT PANEL PROGRAM DISPLAY MESSAGES

The Model 195A has a number of display messages associated with program operation. General display messages that are used with most or all the programs are listed in Table 3-2. Note that many of the programs have additional messages which are covered separately with each program description.

Table 3-2. General Front Panel Program Messages

Message	Description
Pro ?	Prompt for program number.
noPro	Invalid program number.
inPro	Button not applicable to program.
OFLO	Reading out of range.

3.4 PROGRAMMING NOTES

1. Each program is entered by pressing the PRGM button followed by the desired program number.
2. When the PRGM button is pressed, the instrument will prompt for a program number as follows:

Pro ?

3. If an invalid program number is entered, the following message will be displayed for about one second:

noPro

4. If an invalid button is pressed while a program is in progress, the following message will be displayed for about one second:

inPro

5. Program 0 is used to return the user to normal front panel operation.
6. Programs 0 through 9 are mutually exclusive; only one of these programs may be entered at any given time.
7. A new program may be entered without using Program 0 simply by pressing PRGM. The instrument will abort the present program and prompt for a new program number.
8. When a program is in progress, the PRGM indicator will be on. The indicator will go out when the instrument is taken out of the program mode.
9. Numerical constants used for each program are stored separately and will not change unless entered at the appropriate point in the program. Those constants not stored in non-volatile RAM by Program 1 will be lost when the power is turned off. (Only certain Programs 3, 4, 5, 6 and 8 constants can be stored in non-volatile RAM).
10. Constants are to be entered by the operator when prompt to do so by the instrument. When entering a numerical constant:
    A. The constant is entered by pressing the numbered buttons in the desired sequence.
    B. The decimal point and exponent are automatically placed in accordance with the allowable range of the constant.
    C. Data is entered into the digit whose "c" segment is flashing by pressing the desired numbered button. The "c" segment is shown below:

       8 ← "c" segment

       As each digit is entered the flashing segment will move one place to the right until all necessary digits have been entered.
    D. If an invalid key is pressed while entering a constant, the following message will be displayed briefly:

       | inPro |

    E. If too many digits are entered, the display will cycle around to the beginning, but previously entered digits are not affected.
    F. If an incorrect digit is entered, the complete constant must be reentered.
    G. Once the desired constant value is shown on the display, the constant is entered into the program by pressing ENT.

3.5 PROGRAM DESCRIPTIONS

The following paragraphs describe the purpose and operation of the front panel programs. Where needed, examples are included to help clarify program operation.

3.5.1 Program 0. Clear

Program 0 is used to cancel program selection. This program is entered by pressing the PRGM and 0 buttons in sequence as follows:

1. Press PRGM. The instrument will prompt for a program number as follows:

   | Pro ? |

2. Press 0. The program number will be briefly displayed:

   | Pro 0 |

3. Immediately after the program number, the following clear message will be displayed for about ½ second:

   | CLr |

4. The Model 195A will return to normal operation and begin displaying readings.

3.5.2 Program 1. Non-Volatile Storage

Program 1 stores parameters that were entered in Programs 3, 4, 5, 6 and 8 into the non-volatile RAM for future use. These parameters are retained even when the power is turned off. Storage may be inhibited by removing an internal jumper (see Section 7). Program 1 is entered by pressing the PRGM and 1 button in sequence as follows:

1. Press PRGM. The Model 195A will prompt for a program number as follows:

   | Pro ? |

2. Press 1. The instrument displays the program number for about ½ second:

   | Pro 1 |

3. The instrument will then prompt for an input as follows:

   | Stor ? |

4. To perform NV storage, press ENT. The data entered in Program 3, 4, 5 and 8 will be stored in the non-volatile RAM and the instrument will return to normal operation.

NOTES:
1. Program 1 may be aborted at step 4 by pressing PRGM.
2. Only NV parameters entered during the present power-up period of the instrument will be altered by running Program 1.
3. If the calibration jumper has been removed, NVRAM data will not be changed. The instrument will display the following message if NV storage is performed with the jumper removed:

   | no Str |

3.5.3 Program 2. Multiplex

The multiplexer auto zero/cal routines may be defeated by running Program 2. Each time Program 2 is run, the instrument selects the alternate mode (on or off). Using the Model 195A with the auto zero/cal defeated is useful for making high impedance DC voltage measurements which can be affected by the noise spikes generated by zero/cal multiplexing voltages. In this mode, measurements should be made in a stable environment to maintain rated accuracy. It is recommended to periodically exist Program 2 to allow the instrument to re-auto cal and zero itself.

To run Program 2, perform the following steps:

1. Press PRGM. The Model 195A will prompt for a program number as follows:

   `Pro ?`

2. Press 2. The instrument will display the program number for ½ second as follows:

   `Pro 2`

3. If the auto zero/cal routine was disabled, it will now be enabled and the following message will be displayed for ½ second:

   `non`

4. If the auto zero/cal routine was previously enabled, it will now be disabled and the following message will be displayed for ½ second:

   `noFF`

5. After the appropriate message, the instrument resumes normal operation.

NOTES:

1. The displayed message shows the auto zero/cal state of the instrument upon Program 2 exit.
2. If the instrument is not in the desired state after running Program 2, it may be changed to the alternate state by running Program 2 a second time.
3. Auto zero/cal will be enabled upon power-up.

3.5.4 Program 3. IEEE Address and Talk-Only Mode

The IEEE primary address and talk-only mode may be controlled with Program 3. When Program 3 is run, the instrument will prompt for a two-digit input value. The meanings of these values are summarized in Table 3-3. The following steps describe the programming sequence. For more complete information on IEEE-488 operation, refer to Section 4. To enter Program 3, perform the following steps:

1. Press PRGM. The instrument will prompt for a program number:

   `Pro ?`

2. Press 3. The instrument then displays the program number for about ½ second:

   `Pro 3`

3. Following the program number indication, the display will show the previously programmed IEEE parameter. For example, if the primary address is 25, the display will show:

   `IE 25`

4. To enter the displayed parameter into the program without changing it, press the ENT button. The instrument will return to the normal operation mode.
5. To change the IEEE parameter, enter the desired value into the display with the number buttons and then press ENT. The Model 195A will then return to the normal operating mode.

Example: Assume it is desired to operate the instrument in the talk-only mode with the appropriate prefix in the data string. The following button sequence will program the instrument for this operating mode; PRGM; 3; 4; 0; ENT. After the ENT button is pressed, the instrument will be in the talk-only mode.

NOTES:

1. IEEE parameters are not stored in non-volatile RAM unless Program 1 is run.
2. An IEEE parameter entered in Program 3 supersedes the IEEE parameter stored in NVRAM. For example, assume a primary address of 16 is stored in NVRAM and that an address value of 25 has been entered during Program 3 operation. The instrument will then operate with the primary address of 25.
3. If an invalid parameter is entered during Program 3 execution, the following message will be displayed for about ½ second:

   `inPro`

4. The IEEE address or talk-only parameter is briefly displayed upon power-up.

Table 3-3. Program 3 IEEE Parameters

Value	Description
0-30	Primary address = 0-30
40	Talk-only mode with prefix. Example: NDVC +1.23456E−2)
41	Talk-only mode without prefix. (Example: +1.23456E−2)

3.5.5 Program 4. Line Frequency

The programmed line frequency affects the integration period of the instrument in the S1 through S5 rate modes (see Section 4). The Model 195A does not automatically detect the power line frequency upon power-up, instead this value must be set by running Program 4. Note that this program simply toggles the operating frequency between 50Hz and 60Hz; each time Program 4 is entered, the instrument changes to the alternate frequency.

Enter Program 4 as follows:

1. Press PRGM. The Model 195A will prompt for a program number as follows:

   `Pro ?`

2. Press 4. The program number is displayed for about ½ second:

   `Pro 4`

3. If the instrument was programmed for 50Hz, it will change to the 60Hz mode and briefly display the following message:

   `F=60`

4. If the instrument was programmed for 60Hz, it will change to the 50Hz mode and display the following message for ½ second:

   `F=50`

5. After displaying the programmed line frequency, the instrument returns to the normal operating mode.

NOTES:

1. The programmed frequency should be the same as the frequency of the Model 195A's power source. Operating the instrument on the wrong frequency will result in noisier readings.
2. For non-volatile RAM storage of the programmed line frequency, use Program 1 (paragraph 3.5.2).
3. The frequency entered in Program 4 supersedes the frequency stored in NVRAM. For example, if 60Hz is stored in NVRAM, and 50Hz is entered with Program 4, the instrument will operate in the 50Hz mode.
4. The programmed line frequency is briefly displayed upon power-up.

3.5.6 Program 5. Digital Calibration

A major innovation used in the Model 195A is its digital calibration feature. Through use of Program 5, the user can easily calibrate the Model 195A by applying an accurate calibration signal and using this program. The calibration signal can be a prompted value, or a number entered from the front panel. The steps below describe the basic steps for using Program 5. For the complete calibration procedure, refer to Section 7, Maintenance.

Voltage, Resistance and Current Calibration

1. Select the range and function, and zero and filter the instrument, if necessary, before entering Program 5. Do not use autoranging. Do not use zero for ACV or ACA.
2. Connect the calibration source to the instrument. Set the source to the calibration value to be used.
3. Press PRGM. The instrument will prompt for a program number as follows:

   `Pro ?`

4. Press 5. The Model 195A will display the program number for about ½ second:

   `Pro 5`

5. Following the program number, the display will show the default calibration value, which is usually done at 95% of full range. The decimal point and exponent will automatically be set in accordance with the selected range and function. For example, on the 20V range, the display will show:

   `19.0000+0`

6. If the desired calibration value agrees with the displayed value, simply press ENT. If a different calibration value is to be used, key in the value with the number buttons and press ENT.
7. If calibration takes place, the following message will be displayed:

   `CAL`

8. If the calibration procedure is unsuccessful (for example, if no signal applied is greater or equal to two times the displayed value), the following message will be displayed:

   `CAL-E`

   Existing calibration is unaffected under these conditions.
9. Once the ENT button is pressed, the instrument will return to normal operation and begin displaying newly calibrated readings.
10. Repeat steps 1 through 6 for each desired function and range.

Temperature Calibration

1. Press PRGM. The instrument will prompt for a program number as follows:

   `Pro ?`

2. Press 6. The instrument will briefly display the program number:

`Pro 6`

3. Following the program number, the unit will enter the temperature mode. To continue with calibration, press PRGM. The Model 195A will again prompt for a program number:

`Pro ?`

4. Press 5. The instrument will then display the program number followed by a prompt for the alpha parameter as follows:

`ALPHA`

5. Following the prompt, the default alpha value (for the DIN 43 760 standard) will be displayed:

`.00385+0`

6. If the displayed value of alpha is to be used, press ENT. If a new value of alpha is to be used, key in the digits and press ENT (the allowable range of alpha is 0.00360≤ alpha≤0.00420). For example, for the IPTS-68 standard, key in a value of 0.00392.
7. The unit will now prompt for the delta constant with the following message:

`dELtA`

8. After the prompt, the default value (for the DIN 43 760 standard) will be displayed:

`1.50200+0`

9. To use the displayed value, simply press ENT. To change the value, key in the digits and press ENT (the allowable range for delta is 1.4≤delta≤1.6). For example, for the IPTS-68 standard, a value of 1.49633 would be used.
10. The instrument will now display a message prompting for the nominal probe resistance value at 0°C as follows:

`t=0°C`

11. Following the prompt, the default probe resistance at 0°C (for the DIN 43 760 standard) will be displayed:

`100.0000+0`

12. To use the present value, press ENT. To change the value, key in the digits and press ENT. Instrument performance is guaranteed for values between 85Ω and 120Ω, but the user may experiment with a wider range of values.

NOTE

If the precise probe resistance at 0°C is known, key in that value instead of the nominal value for better overall accuracy.

13. The unit will now prompt for operation on either the DIN or NBS (IPTS-68) standard. The importance of this selection lies in proper conformity for temperatures below 0°C. With the NBS standard, the display will appear as follows:

`n Std ?`

14. For the DIN standard, the display will show:

`d Std ?`

15. To select the DIN standard, press the 1 button. To select the NBS standard; press the 2 button. Once the desired standard is displayed, press ENT.
16. The instrument will now prompt for selection of 3-wire or 4-wire operation. For 4-wire operation, the display will appear as follows:

`3or4t 4`

17. Press 3 or 4 to select the desired mode, then press ENT. The unit will then display the following message to indicate that calibration is being performed.

`CAL`

After a few seconds, the unit will return to the normal temperature measurement mode.

NOTE

For permanent storage of calibration constants, Program 1 must be used as described in paragraph 7.5.9. The PRGM light will flash until NVRAM storage is successfully performed.

Example: Assume the Model 195A is to be calibrated on the 2VDC range at a value of 1.95V. After connecting the calibrating signal to the VOLTS OHMS terminals and setting the instrument to the 2VDC range, the operator would key in the following sequence: PRGM; 5; 1; 9; 5; 0; 0; ENT.

NOTES:

1. Program 5 does not automatically store the calibration constants in NVRAM. Program 1 must be used to perform this storage operation.
2. Calibration constants will not be stored in NVRAM Program 1 if the calibration jumper is removed. (See Paragraph 7.5.9)
3. Calibration on the 2VAC range should be done at the following two points: 1.0000V and 0.1000V. The instrument will prompt for two sets of inputs on this range. See Section 7 for complete details.

4. Successfully stored calibration constants supersede those previously stored in NVRAM only during the present power-up cycle.
5. The PRGM light will flash after calibration constants are entered until NVRAM storage is sucessfully performed.

3.5.7 Program 6. Temperature Measurement

Program 6 places the Model 195A in the temperature measurement mode. By connecting a suitable platinum RTD probe to the instrument, measurements in the range of -220°C and +630°C and between -360°F and +1100°F can be made. Enter Program 6 as follows:

1. Press PRGM. The instrument will prompt for a program number as follows:

```
Pro ?
```

2. Press 6. The instrument will briefly display the program number as follows:

```
Pro 6
```

3. Following the program number, the unit will enter the temperature measuring mode; each time the PRGM, 6 key stroke sequence is performed, the instrument will toggle between the °C and °F temperature modes. The flashing decimal point shows the conversion rate.
4. In the °C mode, a typical reading might be:

```
023.00 C
```

For a typical reading in the °F mode, the display might appear as follows:

```
074.00 F
```

5. If the temperature is outside the measuring range of the instrument, or if the probe is open, the following message will be displayed:

```
OFLO
```

6. Place the probe on or in the material to be measured and take the temperature reading. Allow sufficient time for the reading to stabilize.

WARNING

Do not subject the temperature probe to a potential more than 30V RMS, 42.4V peak above earth ground, or a shock hazard may result.

7. To cancel the temperature mode, press a valid FUNCTION button, such as VOLTS.

NOTES

1. The instrument may be operated in either the 4½ digit or 5½ digit resolution mode while in the temperature mode. The RESOLN button on the front panel controls display resolution. When in the 5½ digit mode, the ° character is replaced by the least significant digit of the temperature reading.
2. Temperature measurements may be stored in the internal buffer by entering Program 7 after entering the temperature mode.
3. The instrument may be placed in the one-shot mode when making temperature measurements by using Program 9.
4. As with other Model 195A measurements, the final filtered temperature reading is not displayed until the FILTER light ceases flashing.
5. Program 0 does not cancel the temperature mode.

3.5.8 Program 7. Data Logger

The Model 195A has an internal 100 point data buffer that can be used to log a series of readings. The fill rate of the buffer can be set by a parameter entered when Program 7 is run. Alternately, the one-shot trigger mode can be used to control the fill rate from the front panel or an external trigger source. Once the data is stored, readings can be easily recalled from the front panel. Special recall modes allow the highest buffer reading, lowest buffer reading, or the average of all buffer readings to be displayed. Enter Program 7 as follows:

1. Press PRGM. The Model 195A will prompt for a program number as follows:

```
Pro ?
```

2. Press 7. The instrument will briefly display the program number:

```
Pro 7
```

3. The instrument will now prompt the operator to input the value of r, which controls the logging interval, by displaying the following prompt:

```
r= 8
```

The present r value will be displayed.

4. The r value for the various time intervals are listed in Table 3-4.
5. Enter the desired value of r and press ENT. The instrument will respond with the following message which will alternate with normal readings:

```
StArt?
```

6. At this point, the buffer pointers are reset, but the logging process has not yet begun. To begin storing readings, press the ENT button again.
7. The Model 195A will now begin storing readings at inter-

vals selected by the r constant. The display will continue to display normal readings at the conversion rate.

8. The buffer will be full when all 100 readings have been stored. When this occurs, the following message wil be displayed:

bFULL

This message will alternate with normal readings.

9. Logged data may be recalled any time during the storage process by pressing the RECALL button. The instrument will respond with the number (1-100) of the last stored buffer reading as follows:

n=*

Here the asterisk represents the number of the last stored reading. Note that the decimal point stops flashing while the instrument is in the recall mode. (Also when the PRGM LED is on). Logging continues, but all recalling is only up to this reading.

10. To continue recalling readings, press the RECALL button momentarily. After each buffer number, the reading itself will be displayed. (Normal operation may be restored at this point by pressing 0).
11. To scroll rapidly through the readings, hold the RECALL button in. The reading numbers will rapidly increment in sequence. After 10 address values, the scrolling becomes more rapid.
12. To decrement the reading numbers rather than increment them, press the minus (-) button before using the RECALL button. The reading numbers will decrement with each operation of the RECALL button. Hold the RECALL button in to scroll the readings.
13. To obtain an average up to the displayed address of step 9, during the recall process, press 3. The instrument will respond with the following message for ½ second:

bA

Following this message, the average of all readings in the buffer will be displayed.

14. To obtain the lowest buffer reading, press 2. The Model 195A will respond with the following message for ½ second:

bLO

The message will be followed by the number of the low reading followed by the actual low reading.

15. To obtain the hi-hest reading in the buffer, press 1. The instrument will briefly display the following:

bHI

This message will be followed by the number of the high reading and the reading itself.

16. The instrument may be taken out of the recall mode by pressing 0. The following message will be displayed:

out

NOTES:

1. Logging continues during the recall process as long as the buffer is not full, but front panel triggering is not available during recall.
2. The Model 195A one-shot trigger mode may be used in conjunction with the buffer. When the instrument is in the front panel one-shot trigger mode, one reading will be stored in the buffer each time the TRIG button is operated. (Use r=0 or r=1 for this operating mode.) If r $\geq$ 2, readings will be stored at the interval determined by the r parameter when in the one-shot mode.
3. Logging stops when the buffer is full.
4. Pressing an invalid button during the recall process will result in the following message:

inbuF

5. Buffer operation may be cancelled at step 5 of the above procedure by pressing PRGM.
6. Pressing the RECALL/ENT button when buffer operation is disabled will result in the following display sequence:

n=000

followed by:

out

7. The RECALL button will cancel the "bFULL" message, but stored readings are not affected.
8. The buffer average, low, and high routines do not take into account the decimal point and exponent. Thus, range or function should not be changed during the logging process when these routines are used. The range and function will be indicated on the front panel during the recall process.
9. When the "start?" prompt appears, the unit has entered the data logging program, but logging has not yet been started. Pressing ENT starts the logging process. The PRGM, 0 sequence disables the logging process.

Table 3-4. Program 7 Logging Rates

r Value	Rate
0	Conversion rate (use for one-shot trigger mode).
1	Same as r=0.
2	1 second interval
3	5 second interval
4	10 second interval
5	1 minute interval
6	5 minute interval
7	10 minute interval
8	30 minute interval
9	1 hour interval

3.5.9 Program 8. Diagnostics

Program 8 may be used for self-test diagnostics or as an aid in troubleshooting the Model 195A. Four tests within Program 8 are used in conjunction with the troubleshooting procedures explained in detail in Section 7. Three remaining tests perform ROM, RAM, and display tests. The messages associated with these tests are shown in Table 3-5. Program 8 is also used to program the Model 195A for Model 1950 operation.

To enter Program 8 perform the following steps:

1. Press PRGM. The instrument will display a prompt for a program number:

   `Pro ?`

2. Press 8. The instrument will briefly display the program number as follows:

   `Pro 8`

3. Following the program number, the instrument will perform a RAM and ROM test simultaneously with the display test for a few seconds. Upon completion of the test, an appropriate message (see Table 3-5) will be displayed. The instrument will then prompt for a test number, n, as follows:

   `tESt ?`

4. Using Table 3-5 select an appropriate value, n, for the test; for example, to perform the ROM test press 5. The instrument will perform the selected test.
5. If the instrument passed the ROM test, the following message will be displayed briefly:

   `PASS`

6. If the ROM test failed, the following message will be displayed:

   `r OE`

7. To program the Model 195A for use with the Model 1950 option, press the minus (-) button when the instrument prompts for an input parameter (step 3). If the Model 1950 option is enabled, the instrument will display the following message.

   `AC OP`

8. If Model 1950 option operation is disabled, the instrument will display the following message.

   `noOP`

   (Each time (-) is pressed, option status toggles.)
9. To permanently store Model 1950 status, use Program 1. Since the Model 195A checks option status only upon power-up, it must be momentarily powered down to complete option programming.

NOTES:
1. Program 8 may be cancelled with PRGM.
2. If the RAM test fails, the instrument will skip the ROM test and display the RAM error message.

3.5.10 Program 9. Trigger Mode

Program 9 places the instrument in the one-shot or continuous trigger mode. Each time Program 9 is entered, the instrument changes to the alternate trigger mode. Detailed triggering information is in paragraph 2.7. Program 9 is run by pressing the PRGM and 9 buttons in sequence as follows:

Table 3-5. Program 8 Tests

Test Number (n)	Display Message	Comments
1-4		Used for troubleshooting. See Section 7.
5-6	PASS	Passed ROM, RAM test.
7	-1.8.8.8.8.8:8	Display Test
5	r OE	Failed ROM test.
6	r AE	Failed RAM test.

1. Press PRGM. The instrument will prompt for a program number:

Pro ?

2. Press 9. The instrument will display the program number for ½ second as follows:

Pro 9

3. After displaying the program number, the Model 195A will change to the alternate trigger mode. If the unit was in the continuous mode, it will change to the one-shot mode and the TRIG indicator will turn on.
4. If the instrument was in the one-shot mode, it will change to the continuous mode and the TRIG light will go out.

NOTES:

1. Program 9 may be used to alternate between IEEE one-shot and continuous modes. See Section 4 for details.
2. When in a one-shot trigger mode, one reading will be processed with each trigger stimulus.
3. Other front panel buttons will trigger the instrument in the one-shot mode.

3.6 PROGRAMMING SCALING FACTORS

Front panel Program 5 can be used to multiply the reading by a constant and add an offset value in accordance with the formula $y = mx + b$, where m is the constant and b is the offset value. The basic procedure for calculating the scaling factor is as follows:

1. Set the Model 195A to the desired function and range.
2. Connect the signal to be used as b constant and press the ZERO button.
3. Connect the signal to be used an the value of mx to the input terminals and enter Program 5 using the procedure in paragraph 3.5.6.
4. When the instrument prompts for a calibration input, enter the value of mx $(0 < m < 2)$.
5. Disconnect the mx signal and connect the b value.
6. Disable then enable the zero mode. All subsequent readings will be scaled according to the previously entered factors.

Example: Given a transducer reading of 212Ω at 0 PSI and 32.4Ω at 556 PSI, suppose it is desired to scale the reading so that the 212Ω resistance will read 0Ω while the 32.4kΩ resistance reads 556Ω. This may be done using the following procedure:

1. Place the instrument in the resistance mode and connect a 212Ω resistor to the VOLTS OHMS terminals.
2. Press the ZERO button.
3. Connect a 32.4kΩ resistor to the VOLTS OHMS terminals.
4. Enter Program 5 by pressing PRGM and 5 in sequence.
5. When the instrument prompts for a calibration value, enter 556 into the display.
6. Press ENT and observe that the "CAL" message is properly displayed.
7. Connect the 212Ω resistor in place of the 32.4kΩ unit.
8. Press the ZERO button to disable the zero mode then press ZERO again.
9. Displayed readings will now be scaled according to the previously entered constants; a 212Ω resistance will read 0Ω and a 32.4kΩ resistance will read 556Ω. In between those two limits, the reading will vary in a linear manner.

NOTES:

1. Using Program 5 to scale the readings will affect calibration of the instrument for normal measurements. Only those ranges changed for scaling will be miscalibrated. The instrument may be momentarily powered down to restore normal calibration as long as scaling factors are not stored in NVRAM.
2. The mx scaling factor may be permanently stored by running Program 1. This will miscalibrate the instrument on affected ranges and functions.
3. The b factor cannot be permanently stored and must be reentered each time the instrument is powered-up.
4. This procedure should not be used on the 2VAC range.
5. The scaling procedure requires that all ranges be properly calibrated because proper calibration of some ranges requires that other ranges also be properly calibrated.

SECTION 4
IEEE-488 OPERATION

4.1 INTRODUCTION

The IEEE-488 bus is an instrumentation data bus with standards adopted by the IEEE (Institute of Electrical and Electronic Engineers) in 1975 and given the IEEE-488 designation. The most recent revision of bus standards was made in 1978; hence the complete description for current bus standards is the IEEE-488-1978 designation. The Model 195A conforms to 1978 standards.

This section contains general bus information as well as detailed programming information and is divided as follows:

1. General introductory information pertaining to the IEEE-488 bus may be found primarily in paragraphs 4.2 through 4.6.
2. Information necessary to connect the Model 195A to the bus is contained in paragraphs 4.7 and 4.8.
3. Programming of the instrument with general bus command is covered in paragraph 4.9.
4. Device-dependent command programming is described in detail in paragraph 4.10. The commands outlined in this section can be considered to be the most important since they control virtually all instrument functions.
5. Additional information pertaining to front panel error messages and controller programs can be found in paragraphs 4.11 and 4.12.

4.2 BUS DESCRIPTION

The IEEE-488 bus was designed as a parallel data transfer medium to optimize data transfer without using an excessive number of bus lines. In keeping with this goal, the bus has only eight data lines that are used for both data and most commands. Five bus management lines and three handshake lines round out the complement of signal lines. Since the bus is of parallel design, all devices connected to the bus have the same information available simultaneously. Exactly what is done with the information by each device depends on many factors, including device capabilities.

A typical bus configuration for controlled operation is shown in Figure 4-1. The typical system will have one controller and one or more instruments to which commands are given and, in most cases, from which data is received. Generally, there are three categories that describe device operation. These designations include: controller; talker; listener.

The controller does what its name implies: it controls other devices on the bus. A talker sends data, while a listener receives data. Depending on the instrument, a particular device may be a talker only, a listener only, or both a talker and listener.

Any given system can have only one controller (control may be passed to an appropriate device through a special command), but any number of talkers or listeners may be present up to the hardware constraints of the bus. Generally, the bus is limited to 15 devices, but this number may be reduced if higher than normal data transfer rates are required or if longer than normal cables are used.

Several devices may be commanded to listen at once, but only one device may be a talker at any given time. Otherwise, communications would be scrambled much like an individual's trying to pick out a single conversation out of a large crowd.

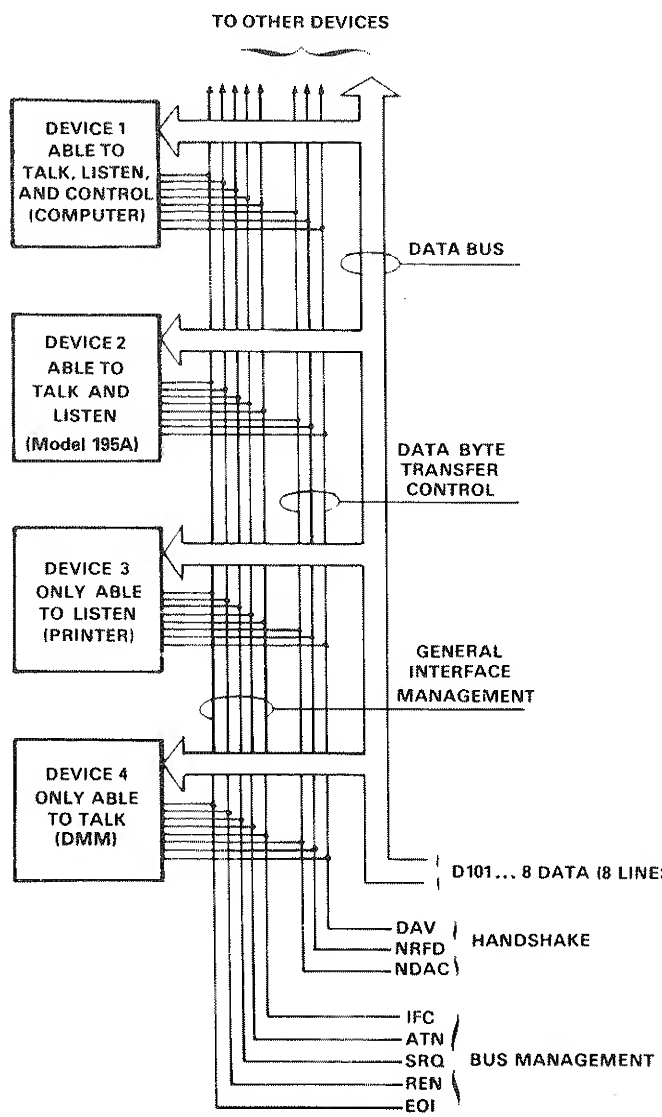


Figure 4-1. IEEE Bus Configuration

Before a device can talk or listen, it must be appropriately addressed. Devices are selected on the basis of their primary address; the addressed device is sent a talk or listen command derived from its primary address. Normally, each device on the bus has a unique primary address so that each may be addressed individually. The bus also has another addressing mode called secondary addressing, but not all devices use this addressing mode.

Once the device is addressed to talk or listen, appropriate bus transactions are set to take place. For example, if an instrument is addressed to talk, it will usually place its data on the bus one byte at a time. The listening device will then read this information, and the appropriate software can then be used to channel the information to the desired location.

4.3 IEEE-488 BUS LINES

The signal lines on the IEEE-488 bus are grouped into three general categories. The data lines handle bus information, while the handshake and bus management lines ensure that proper data transfer and bus operation takes place. Each of the bus lines is active low so that approximately zero volts is a logic one. The following paragraphs describe the purpose of these lines, which are shown in Figure 4-1.

4.3.1 Bus Management Lines

The bus management group is made up of five signal lines that help ensure an orderly transfer of data. These lines are used to send the uniline commands described in paragraph 4.4.1.

1. ATN (Attention)—The ATN line is one of the more important management lines. The state of the ATN line determines whether controller information on the data bus is to be considered data or a multiline command as described in paragraph 4.4.
2. IFC (Interface Clear)—Setting the IFC line true (low) causes the bus to go to a known state.
3. REN (Remote Enable)—Setting the REN line low sends the REN command. This sets up instruments on the bus for remote operation.
4. EOI (End Or Identify)—The EOI line is used to send the EOI command that usually terminates a mulit-byte transfer sequence.
5. SRQ (Service Request)—The SRQ line is set low by a device when it requires service from the controller.

4.3.2 Handshake Lines

The bus uses three handshake lines that operate in an interlocked sequence. This method ensures reliable data transfer regardless of the transfer rate. Generally, data transfer will occur at a rate determined by the slowest active device on the bus.

One of the handshake lines is controlled by the data source, while the remaining two lines are controlled by accepting devices. The three bus handshake lines are:

1. DAV (Data Valid)—The source controls the state of the DAV line.
2. NRFD (Not Ready For Data)—The acceptor controls the state of the NRFD line.
3. NDAC (Not Data Accepted)—The acceptor also controls the NDAC line.

The complete handshake sequence for one data byte is shown in Figure 4-2. Once data is on the bus, the source checks to see that NRFD is high, indicating that all devices on the bus are ready for data. At the same time NDAC should be low from the previous byte transfer. If these conditions are not met, the source must then wait until the NRFD and NDAC lines have the correct status. If the source is a controller, NRFD and NDAC must remain stable for at least 100ns after ATN is set low. Because of the possibility of bus hang up, some controllers have time-out routines to display error messages if the handshake sequence stops for any reason.

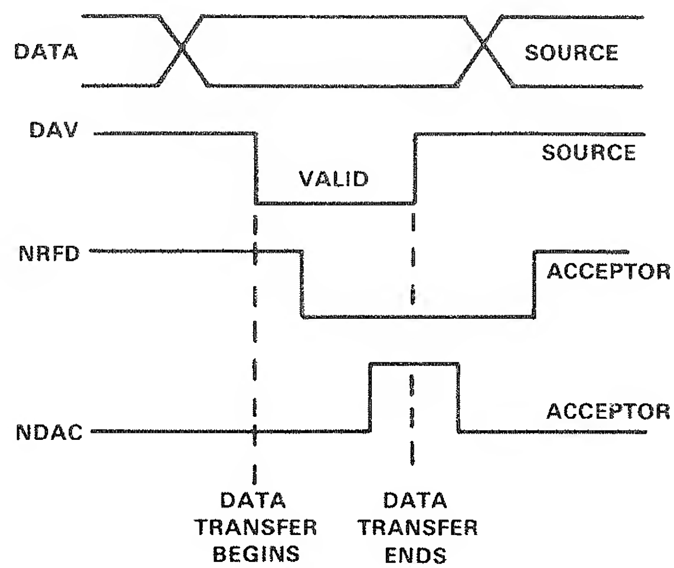


Figure 4-2. IEEE Handshake Sequence

Once the NRFD and NDAC lines are properly set, the source sets the DAV line low, indicating that data on the bus is now valid. The NRFD line then goes low; the NDAC line goes high once all devices on the bus have accepted the data. Each device will release the NDAC line at its own rate, but the NDAC line will not go high until the slowest device has accepted the data byte.

After the NDAC line goes high, the source then sets the DAV line high to indicate that the data on the bus is no longer valid. At this point, the NDAC line returns to its low state. Finally, the NRFD line is released by each of the devices at their own rates, until the NRFD line finally goes high when the slowest device is ready, and the bus is set to repeat the sequence with the next data byte.

The sequence just described is used to transfer both data and multiline commands. The state of the ATN line determines whether the data bus contains data or commands as described in paragraph 4.4.

4.3.3 Data Lines

The IEEE-488 bus uses the eight data lines that allow data to be transmitted and received in a bit-parallel, byte-serial manner. These eight lines use the convention D101 through D108 instead of the more common D0 through D7 binary terminology. The data lines are bidirectional and, as with the remaining bus signal lines, low is true.

4.4 BUS COMMANDS

While the hardware aspects of bus is essential, the interface would be essentially worthless without appropriate commands to control communications between the various instruments on the bus. This paragraph briefly describes the purpose of the bus commands, which are grouped into the following three general categories:

1. Uniline commands: Sent by setting the associated bus line low.
2. Multiline commands: General bus commands which are sent over the data lines with the ATN line low (true).
3. Device-dependent commands: Special commands that depend on device configuration; sent over the data lines with ATN high (false).

These commands are summarized in Table 4-1.

4.4.1 Uniline Commands

Uniline commands are sent by setting the associated bus line low. The ATN, IFC, and REN commands are asserted only by the system controller. The SRQ command is sent by an external device. The EOI command may be sent by either the controller or an external device depending on the direction of data transfer. The following is a brief description of each command.

1. REN (Remote Enable)—When the controller sends the REN command, the instrument will be set up for remote operation. Generally, the REN command should be sent before attempting to program instruments over the bus.
2. EOI (End Or Identify)—The EOI command is used to positively identify the last byte in a multi-byte transfer sequence. This allows variable length data words to be transmitted easily.
3. IFC (Interface Clear)—The IFC command is sent to clear the bus and set devices to a known state. Although device configurations differ, the IFC command usually places instruments in the talk and listen idle states.
4. ATN (Attention)—The controller sends ATN while transmitting addresses or multiline commands. Device-dependent commands are sent with the ATN line high (false).
5. SRQ (Service Request)—The SRQ command is asserted by an external device when it requires service from the controller. If more than one device is present, a serial polling sequence, as described in paragraph 4.9.8, must be used to determine which device has requested service.

Table 4-1. IEEE-488 Bus Command Summary

Command Type	Command	State of ATN Line*	Comments
Uniline	REN (Remote Enable)	X	Set up for remote operation.
	EOI	X	Sent by setting EOI low.
	IFC (Interface Clear)	X	Clears Interface
	ATN (Attention)	Low	Defines data bus contents.
	SRQ (Service Request)	X	Controlled by external device.
Multiline			
Universal	LLO (Local Lockout)	Low	Locks out front panel controls.
	DCL (Device Clear)	Low	Returns device to default conditions.
	SPE (Serial Poll Enable)	Low	Enables serial polling.
	SPD (Serial Poll Disable)	Low	Disables serial polling.
Addressed	SDC (Selective Device Clear)	Low	Returns unit to default conditions.
	GTL (Go to Local)	Low	Returns to local control.
	GET (Group Execute Trigger)	Low	Triggers device for reading.
Unaddressed	UNL (Unlisten)	Low	Removes all listeners from bus.
	UNT (Untalk)	Low	Removes all talkers from bus.
Device-dependent**		High	Programs Model 195A for various modes.

*X = Don't Care
**See paragraph 4.10 for complete description.

4.4.2 Universal Commands

Universal commands are multiline commands that require no addressing. All instrumentation equipped to implement the command will do so simultaneously when the command is transmitted over the bus. As with all multiline commands, the universal commands are sent over the data lines with ATN low.

1. LLO (Local Lockout)—The LLO command is used to lock out front panel controls on devices so equipped.
2. DCL (Device Clear)—After a DCL is sent, instrumentation equipped to implement the command will revert to a known state. Usually, instruments return to their power-up conditions.
3. SPE (Serial Poll Enable)—The SPE command is the first step in the serial polling sequence, which is used to determine which instrument has requested service with the SRQ command.
4. SPD (Serial Poll Disable)—The SPD command is sent by the controller to remove all instrumentation on the bus from the serial poll mode.

4.4.3 Addressed Commands

Addressed commands are multiline commands that must be preceded by a listen command derived from the device's primary address before the instrument will respond. Only the addressed device will respond to each of these commands:

1. SDC (Selective Device Clear)—The SDC command performs essentially the same function as the DCL command except that only the addressed device will respond. Instruments usually return to their default conditions when the SDC command is sent.
2. GTL (Go To Local)—The GTL command is used to remove instruments from the remote mode of operation. Also, front panel control operation will usually be restored if the LLO command was previously sent.
3. GET (Group Execute Trigger)—The GET command is used to trigger devices to perform a specific action that depends on device configuration. Although GET is considered to be an addressed command, many devices respond to GET without being addressed.

4.4.4 Unaddress Commands

The two unaddress commands are used by the controller to remove all talkers and listeners from the bus simultaneously. ATN is low when these multiline commands are asserted.

1. UNL (Unlisten)—All listeners are removed from the bus at once when the UNL command is placed on the bus.
2. UNT (Untalk)—The controller sends the UNT command to clear the bus of any talkers.

4.4.5 Device-Dependent Commands

The meaning of the device-dependent commands is determined by instrument configuration. Generally, these commands are sent as one or more ASCII characters that tell the device to perform a specific function. For example, F0 is sent to the Model 195A to place the instrument in the DCV mode. The IEEE-488 bus treats device-dependent commands as data in that ATN is high (false) when the commands are transmitted.

4.5 COMMAND CODES

Each multiline command is given a unique code that is transmitted over the data bus as 7-bit ASCII data. This section briefly explains the code groups which are summarized in Figure 4-3. Every command is sent with ATN low.

1. Addressed Command Group (ACG)—Addressed commands are listed in column 0(B) in Figure 4-3. Column 0(A) lists the corresponding ASCII codes.
2. Universal Command Group (UCG)—Columns 1(A) and 1(B) list the Universal commands and the corresponding ASCII codes.
3. Listen Address Group (LAG)—Columns 2(A) and 3(A) list the ASCII codes corresponding to the primary address listed in columns 2(B) and 3(B). For example, if the primary address of the instrument is set to 16, the LAG byte will correspond to an ASCII zero.
4. Talk Address Group (TAG)—TAG primary address values and the corresponding ASCII characters are listed in columns 4(A) through 5(B).

The preceding address groups are combined together to form the Primary Command Group (PCG). The bus also has another group of commands, called the Secondary Command Group (SCG). These are listed in Figure 4-3 for informational purposes only; the Model 195A does respond to these commands, but other devices may have secondary addressing capability.

NOTE

Commands are normally transmitted with the 7-bit code listed in Figure 4-3. For most devices, the condition of D_7 (D108) is unimportant, as shown by the "Don't Care" indication in the table. Some devices, however, may require that D_7 assumes a specific logic state before the commands are recognized.

Hexadecimal and decimal values for each of the commands or command groups are listed in Table 4-2. Each value in the table assumes that D_7 is set to 0.

4.6 COMMAND SEQUENCES

The proper command sequence must be sent by the controller before an instrument will respond as intended. The universal commands, such as LLO and DCL, require only that ATN be set low before the command is sent. Other commands require that the device be addressed to listen first. This section briefly describes the bus sequence for several types of commands.

Table 4-2. Hexadecimal and Decimal Command Codes

Command	Hex Value*	Decimal Value
GTL	01	1
SDC	04	4
GET	08	8
LLO	11	17
DCL	14	20
SPE	18	24
SPD	19	25
LAG	20-3F	32-63
TAG	40-5F	64-95
UNL	3F	63
UNT	5F	95

*Values shown with $D_7=0$.

4.6.1 Addressed Command Sequence

Before a device will respond to one of these commands, it must receive a LAG command derived from its primary address. Table 4-3 shows a typical sequence for the SDC command. The LAG command assumes that the instrument is set at a primary address of 16.

Note that an UNL command is transmitted before the LAG, SDC sequence. This is generally done to remove all other listeners from the bus first so that only the addressed device responds.

Table 4-3. Typical Addressed Command Sequence

Step	Command	ATN State	Data Bus ASCII	Data Bus Hex	Data Bus Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	0	30	48
3	SDC	Stays low	EOT	04	4
4		Returns high			

*Assumes primary address = 16.

4.6.2 Universal Command Sequence

The universal commands are sent by setting ATN low and then placing the command byte on the bus. For example, the following gives the LLO command:

ATN • LLO

Note that both the ATN and LLO commands are on the bus simultaneously. Also, addressing is not necessary.

4.6.3 Device-Dependent Command Sequence

Device-dependent commands are transmitted with ATN high. However, the device must be addressed to listen first before the commands are transmitted. Table 4-4 shows the sequence for the following command:

F0X

This command, which sets the Model 195A to the DCV mode, is described in detail in paragraph 4.10.2.

Table 4-4. Typical Device-Dependent Command Sequence

Step	Command	ATN State	Data Bus ASCII	Data Bus Hex	Data Bus Decimal
1	UNL	Set low	?	3F	63
2	LAG*	Stays low	0	30	48
3	Data	Set high	F	46	70
4	Data	Stays high	0	30	48
5	Data	Stays high	X	58	88

*Assumes primary address = 16.

4.7 HARDWARE CONSIDERATIONS

Before the Model 195A can be used with the IEEE-488 bus, the instrument must be connected to the bus with a suitable connector. Also, the primary address must be properly programmed as described in this section.

4.7.1 Typical Controlled Systems

The IEEE-488 bus is a parallel interface system. As a result, adding more devices is simply a matter of using more cables to make the desired connections. Because of this flexibility, system complexity can range from the very simple to extremely complex.

Figure 4-4 shows two typical system configurations. Figure 4-4(a) shows the simplest possible controlled system. The controller is used to send commands to the instrument, which sends data back to the controller.

The system becomes more complex in Figure 4-4(b), where additional instrumentation is added. Depending on programming, all data may be routed through the controller, or it may be transmitted directly from one instrument to another.

For very complex applications, a much larger computer can be used. Tape drives or disks can then be used to store data.

4.7.2 Bus Connections

The Model 195A is connected to the bus through an IEEE-488 connector which is shown in Figure 4-5. This connector is designed to be stacked to allow a number of parallel connections on one instrument.

NOTE

To avoid possible mechanical damage, it is recommended that no more than three connectors be stacked on any one instrument. Otherwise, the resulting strain may cause internal damage.

D_7 D_6 D_5 D_4 Bits					X 0 0 0	COMMAND	X 0 0 1	COMMAND	X 0 1 0	PRIMARY ADDRESS	X 0 1 1	PRIMARY ADDRESS	X 1 0 0	PRIMARY ADDRESS	X 1 0 1	PRIMARY ADDRESS	X 1 1 0		X 1 1 1	
D_3 ↓	D_2 ↓	D_1 ↓	D_0 ↓	COLUMN → ROW ↓	0 (A)	0 (B)	1 (A)	1 (B)	2 (A)	2 (B)	3 (A)	3 (B)	4 (A)	4 (B)	5 (A)	5 (B)	6 (A)	6 (B)	7 (A)	7 (B)
0	0	0	0	0	NUL		DLE		SP	0	0	16	@	0	P	16			p	
0	0	0	1	1	SOH	GTL	DC1	LLO	!	1	1	17	A	1	Q	17	a		q	
0	0	1	0	2	STX		DC2		"	2	2	18	B	2	R	18	b		r	
0	0	1	1	3	ETX		DC3		#	3	3	19	C		S	19	c		s	
0	1	0	0	4	EOT	SDC	DC4	DCL	$	4	4	20	D	4	T	20	d		t	
0	1	0	0	5	ENQ	PPC*	NAK	PPU*	%	5	5	21	E	5	U	21	e		u	
0	1	1	0	6	ACK		SYN		&	6	6	22	F	6	V	22	f		v	
0	1	1	1	7	BEL		ETB		'	7	7	23	G	7	W	23	g		w	
1	0	0	0	8	BS	GET	CAN	SPE	(	8	8	24	H	8	X	24	h		x	
1	0	0	1	9	HT	TCT*	EM	SPD	)	9	9	25	I	9	Y	25	i		y	
1	0	1	0	10	LF		SUB		*	10	:	26	J	10	Z	26	j		z	
1	0	1	1	11	VT		ESC		+	11	;	27	K	11	[	27	k		{	
1	1	0	0	12	FF		FS		,	12	<	28	L	12	\	28	l		:	
1	1	0	1	13	CR		GS		–	13	=	29	M	13	]	29	m		}	
1	1	1	0	14	SO		RS		.	14	>	30	N	14	^	30	n		~	
1	1	1	1	15	SI		US		/	15	?	UNL	O	15	_	UNT	o		DEL	

ADDRESSED COMMAND GROUP (ACG) — columns 0 (A), 0 (B)

UNIVERSAL COMMAND GROUP (UCG) — columns 1 (A), 1 (B)

LISTEN ADDRESS GROUP (LAG) — columns 2 (A) to 3 (B)

TALK ADDRESS GROUP (TAG) — columns 4 (A) to 5 (B)

PRIMARY COMMAND GROUP (PCG) — columns 0 (A) to 5 (B)

SECONDARY COMMAND GROUP (SDC) — columns 6 (A) to 7 (B)

*PPC (Parallel Poll Configure), PPU (Parallel Poll Unconfigure), and TCT (Take Control) not implemented by Model 2243

NOTE: D_0 = DIO1...D_7 = DIO8
X = Don't Care

Figure 4-3. Command Code

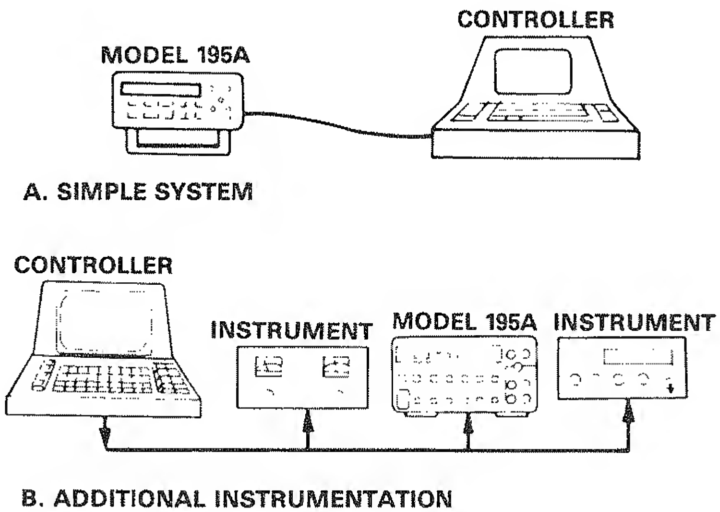


Figure 4-4. System Types

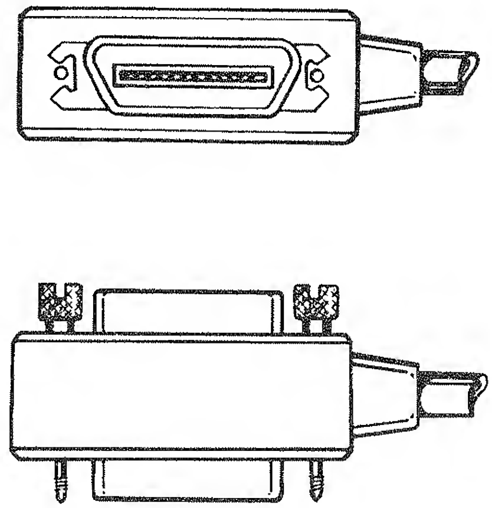


Figure 4-5. IEEE-488 Connector

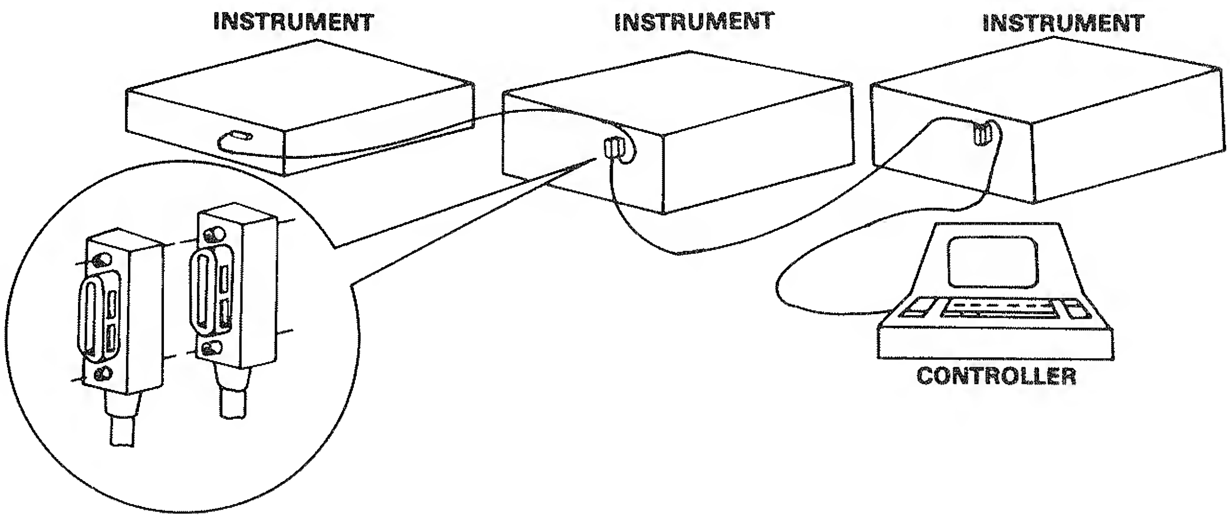


Figure 4-6. IEEE-488 Connections

A typical connecting scheme for the bus is shown in Figure 4-6. Each cable normally has the standard IEEE connector on each end. The Keithley Model 7008-3 or 7008-6 cable is ideal for this purpose. Once the connections are made, the screws should be tightened securely. For the location of the connector on the rear panel of the Model 195A, refer to Figure 4-7.

NOTE

The IEEE-488 bus is limited to a maximum of 15 devices, including the controller. Also, the maximum cable length is 20 meters. Failure to observe these limits will probably result in erratic bus operation.

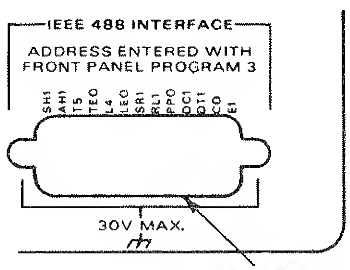


Figure 4-7. Rear Panel of Model 195A Showing IEEE Connectors

Custom cables may be constructed using the information in Table 4-6 and Figure 4-5. Table 4-5 lists the contact assignments for the various bus lines, while Figure 4-8 shows contact designations. Contacts 18 through 24 are return lines for the indicated signal lines, and the cable shield is connected to contact 12. Each ground line is connected to digital common in the Model 195A.

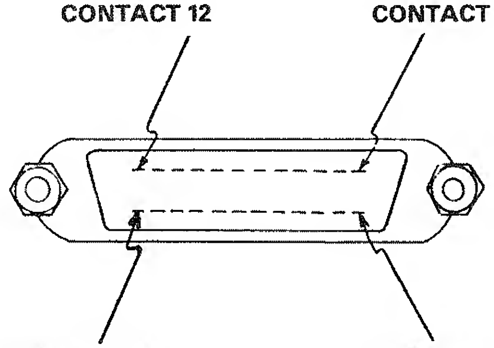


Figure 4-8. Contact Assignments

CAUTION

The voltage between IEEE common and ground must not exceed 30V or damage to the instrument may occur.

Table 4-5. IEEE Contact Designations

Contact Number	IEEE-488 Designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI (24)*	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN (24)*	Management
18	Gnd, (6)*	Ground
19	Gnd, (7)*	Ground
20	Gnd, (8)*	Ground
21	Gnd, (9)*	Ground
22	Gnd, (10)*	Ground
23	Gnd, (11)*	Ground
24	Gnd, LOGIC	Ground

*Numbers in parentheses refer to signal ground return of referenced contact number. EOI and REN signal lines return on contact 24.

A typical signal line bus driver is shown in Figure 4-9. With the configuration shown, the driver has bidirectional capability. When the I/O control line is high, the line is configured as an output line. When the control line is low, the driver is set up for input operation. Note that not all signal lines have bidirectional capability. Some lines, such as ATN, will always be configured as an output line in the controller and as an input line for all other devices on the bus.

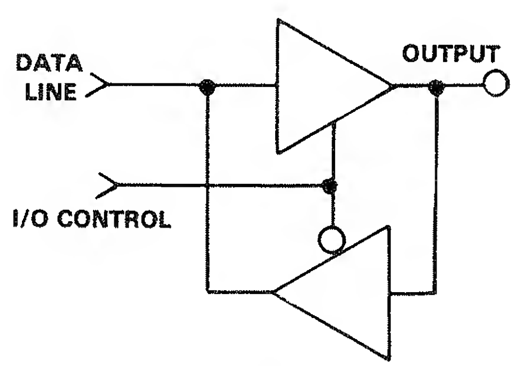


Figure 4-9. Typical IEEE-488 Bus Driver (One of 16)

4.7.3 Primary Address Programming

The Model 195A must receive a listen command before it will respond to addressed commands. Similarly, the instrument must receive a talk command before it will transmit its data string, status word, or status byte. These listen and talk commands are derived from the instrument's primary address. The Model 195A is shipped from the factory with a programmed primary address of 16. The primary address may be programmed to any value between 0 and 30 as long as address conflicts with other bus instruments are avoided. This may be done by running front panel Program 3. Note that the primary address of the instrument must agree with the address specified in the controller's programming language.

NOTE

The programmed primary address is briefly displayed as part of the power-up cycle.

To check the present primary address, or enter a new one, enter Program 3 as follows:

1. Press the PRGM and 3 (AUTO) buttons in sequence.
2. The Model 195A will display the present primary address. For example, with the factory programmed value, the display will show the following:

IE 16

3. To leave the address unchanged simply press ENT. To change the address, enter a new value between 0 and 30 and press ENT.

NOTES:

1. The Program 3 input sequence is described in more detail in paragraph 3.5.4.
2. Each device on the bus must have a unique primary address. Failure to observe this precaution may result in erratic bus operation.
3. For permanent storage of the programmed primary address, front panel Program 1 must be used to enable non-volatile storage. See paragraph 3.5.2 for details.

4.7.4 Talk-Only Mode

The Model 195A may be placed in the talk-only mode and be used with a listen-only device such as a printer. When in this mode, the instrument will ignore commands given over the bus and merely output data as requested.

The talk-only mode may be entered by entering one of the following parameters into Program 3:

40 Talk-only mode with prefixes and suffixes on data string (Example: NDCV-1.23456E-1)

41 Talk-only mode without prefixes and suffixes on data string (Example: -1.23456E-1)

To enter the talk-only mode, perform the following steps:

1. Press the PRGM and 3 buttons in sequence.
2. To enter the talk-only with prefix mode, press 4, 0, and ENT in sequence.
3. To cancel the talk-only mode, enter Program 3 and enter the desired primary address value.

NOTES:

1. The talk-only mode will be cancelled when the instrument is turned off unless the talk-only parameter is stored in non-volatile RAM by Program 1. (paragraph 3.5.2)
2. The Program 3 input sequence is described in more detail in paragraph 3.5.4.

4.8 SOFTWARE CONSIDERATIONS

The most sophisticated computer in the world would be useless without the necessary software. This basic requirement is also true of the IEEE-488 bus, which requires the use of handler routines as described in this paragraph.

4.8.1 Controller Interface Routines

Before a controller can be used with the IEEE-488 interface, the user must make certain that appropriate handler software is present within the controller. With the HP-85 computer, for example, the HP-85 interface card must be used with an additional I/O ROM, which contains the necessary handler software.

Other small computers that can be used as controllers have limited IEEE command capability. The PET/CBM computers, for example, are incapable of sending multiline commands from BASIC, although these commands can be sent through machine-language routines. The capabilities of other small computers depends on the particular interface being used. Often, little software "tricks" are required to achieve the desired results.

From the preceding discussion, the message is clear: make sure the proper software is being used with the interface. Often, the user may incorrectly suspect that a hardware problem is causing fault, when it was the software that was causing the problem all along.

4.8.2 HP-85 BASIC Statements

Many of the programming instructions covered in this section use examples written in Hewlett-Packard Model 85 BASIC. The HP-85 was chosen for these examples because it has a large number of BASIC statements that control IEEE-488 operation. This section covers those HP-85 BASIC statements that are essential to Model 195A operation.

A complete list of HP-85 IEEE-488 BASIC statements is shown in Table 4-6. All the statements in the table have one or three digit arguments that must be specified. The first digit

is the HP-85 interface select code, which is set to 7 at the factory. The last two digits of those statements that require a three digit argument specify the primary address. Generally, only those commands that actually require an address to be sent over the bus require that the primary address be specified in the BASIC statement.

Those statements in the table with three digit arguments assume that the primary address of the device is set at 16. Other primary addresses require that the last two digits be set to the corresponding value. For example, to send a GTL command to device 22, the following BASIC statement would be used: LOCAL 722.

Some of the statements in the table have two forms; the exact configuration used depends on the desired command. For example, CLEAR 7 will cause a DCL to be sent, while CLEAR 716 causes an SDC to be transmitted to device 16.

The third column of Table 4-6 lists the mnemonics for the command sequences. While most of these are covered elsewhere, a couple of points should be noted. As described earlier, the ATN line is set low by the controller if the data bus contains a multiline command. This is indicated in the table by ANDing the ATN mnemonic with the first command on the bus. For example, ATN•GET means that ATN and GET are sent simultaneously.

Two commands not previously covered are MLA (My Listen Address) and MTA (My Talk Address). These are ordinary PCG (Primary Command Group) addresses sent by the HP-85 to facilitate bus operation in some situations. The Model 195A will essentially ignore these commands, but other devices may require that MLA and MTA be present in the command sequence under certain circumstances.

NOTE

The HP-85 address is set to 21 at the factory. Since each device on the bus must have a unique primary address, do not program the Model 195A for the controller's address to avoid possible conflicts.

4.8.3 Interface Function Codes

The interface function codes are part of the IEEE-488-1978 standards. These codes define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual.

Table 4-7 lists the codes for the Model 195A. These codes are also listed for convenience on the rear panel of the instrument immediately above the IEEE connector. The numeric value following each one or two letter code defines Model 195A capabilities as follows:

1. SH (Source Handshake Function)—The ability for the Model 195A to initiate the transfer of message/data on the data bus is provided by the SH function.
2. AH (Acceptor Handshake Function)—The ability for the Model 195A to guarantee proper reception of message/data on the data is provided by the AH function.
3. T (Talker Function)—The ability for the Model 195A to send device-dependent data over the bus (to other devices) is provided by the T function. Model 195A talker capabilities exist only after the instrument has been addressed to talk.
4. L (Listener Function)—The ability for the Model 195A to receive device- dependent data over the bus (from other devices) is provided by the L function. Listener function

Table 4-6. HP-85 IEEE-488 BASIC Statements

Statement	Action	Bus Command Sequence
ABORTIO 7	Send IFC.	IFC
CLEAR 7	Send DCL.	ATN•DCL
CLEAR 716	Send SDC to device 16.	ATN•UNL;MTA;LAG;SDC
ENTER 716;A$	Device 16 addressed to talk. Data placed in A$.	ATN•UNL;MLA;TAG;$\overline{\text{ATN}}$;data
LOCAL 716	Send GTL to device 16.	ATN•UNL;MTA;LAG;GTL
LOCAL LOCKOUT 7	Send LLO.	ATN•LLO
OUTPUT 716;A$	Device 16 addressed to listen. Transmit A$.	ATN•MTA;UNL;LAG;$\overline{\text{ATN}}$;data
REMOTE 7	Set REN true.	REN
REMOTE 716	Set REN true. Address device 16 to listen.	REN;ATN•UNL;MTA;LAG
RESET 7	Send IFC, cancel REN.	IFC;REN;$\overline{\text{REN}}$
SPOLL(716)	Address device 16 to talk. Conduct serial poll.	ATN•UNL;MLA;TAG;SPE;$\overline{\text{ATN}}$; status byte;ATN•SPD;UNT
TRIGGER 7	Send GET	ATN•GET
TRIGGER 716	Address device 16 to listen. Send GET.	ATN•UNL;MTA;LAG:GET

capabilities of the Model 195A exist only after it has been addressed to listen.

5. SR (Service Request Function)—The ability for the Model 195A to request service from the controller is provided by the RL function.
6. RL (Remote-Local Function)—The ability for the Model 195A to be placed in the remote or local modes is provided by the RL function.
7. PP (Parallel Poll Function)—The Model 195A does not have parallel polling capabilities.
8. DC (Device Clear Function)—The ability for the Model 195A to be cleared (initialized) is provided by the DC function.
9. DT (Device Clear Function)—The ability for the Model 195A to have its readings triggered is provided by the DT function.
10. C (Controller Function)—The Model 195A does not have controller capabilities.
11. TE (Extended Talker Capabilities)—The Model 195A does not have extended talker capabilities.
12. LE (Extended Listener Capabilities)—The Model 195A does not have extended listener capabilities.

Table 4-7. Model 195A Interface Function Codes

Code	Interface Function
SH1	Source Handshake Capability
AH1	Acceptor Handshake Capability
T5	Talker (Basic Talker, Serial Poll, Talk Only Mode, Unaddressed To Talk On LAG)
L4	Listener (Basic Listener, Unaddressed To Listen On TAG)
SR1	Service Request Capability
RL1	Remote/Local Capability
PP0	No Parallel Poll Capability
DC1	Device Clear Capability
DT1	Device Trigger Capability
C0	No Controller Capability
E1	Open Collector Bus Drivers
TE0	No Extended Talker Capabilities
LE0	No Extended Listener Capabilities

4.8.4 Model 195A Interface Commands

Interface commands controlling Model 195A operation are listed in Table 4-8. Not included in the table are device-dependent commands, which are covered in detail in paragraph 4.10.

4.9 GENERAL BUS COMMAND PROGRAMMING

General bus commands are those commands which have the same general meaning regardless of instrument configuration. These commands are grouped into two categories:

1. Addressed Commands—These commands require that the primary address of the instrument agrees with the primary address in the controller's programming language.

Table 4-8. IEEE Command Groups

HANDSHAKE COMMAND GROUP	
	DAC = DATA ACCEPTED
	RFD = READY FOR DATA
	DAV = DATA VALID
UNIVERSAL COMMAND GROUP	
	ATN = ATTENTION
	DCL = DEVICE CLEAR
	IFC = INTERFACE CLEAR
	LLO = LOCAL LOCKOUT
	REN = REMOTE ENABLE
	SPD = SERIAL POLL DISABLE
	SPE = SERIAL POLL ENABLE
ADDRESS COMMAND GROUP	
LISTEN:	LAG = LISTEN ADDRESS GROUP
	MLA = MY LISTEN ADDRESS
	UNL = UNLISTEN
TALK:	TAG = TALK ADDRESS GROUP
	MTA = MY TALK ADDRESS
	UNT = UNTALK
	OTA = OTHER TALK ADDRESS
ADDRESSED COMMAND GROUP	
	ACG = ADDRESSED COMMAND GROUP
	GET = GROUP EXECUTE TRIGGER
	GTL = GO TO LOCAL
	SDC = SELECTIVE DEVICE CLEAR
STATUS COMMAND GROUP	
	RQS = REQUEST SERVICE
	SRQ = SERIAL POLL REQUEST
	STB = STATUS BYTE
	EOI = END

2. Unaddressed Commands—No primary address is required for these commands. All devices equipment to implement these commands will do so simultaneously when the command is sent.

General bus commands are summarized in Table 4-9, which also lists the HP-85 BASIC statement that sends each command. Each addressed command statement assumes a primary address of 16.

NOTE

The Model 195A must be programmed for a primary address of 16 to work with addressed command examples.

4.9.1 REN (Remote Enable)

The remote enable command is sent to the Model 195A by the controller to set the instrument up for remote operation. Generally, this should be done before attempting to program the instrument over the bus. The Model 195A will indicate that it is in the remote mode by illuminating its front panel REMOTE indicator.

To place the Model 195A in the remote mode, the controller

must perform the following steps:

1. Set the REN line true.
2. Address the Model 195A to listen.

Table 4-9 General Bus Commands

Command	Addressing Required ?	HP-85 BASIC Statement
REN	Yes	REMOTE 716
IFC	No	ABORTIO 7
LLO	No	LOCAL LOCKOUT 7
GTL	Yes	LOCAL 716
DCL	No	CLEAR 7
SDC	Yes	CLEAR 716
GET*	Yes	TRIGGER 716
GET*	No	TRIGGER 7

*GET may be sent with or without addressing.

NOTE

Setting REN true without addressing will not cause the REMOTE indicator to turn on; however, once REN is true, the REMOTE light will turn on the next time an addressed command is received.

Programming Example—This sequence is automatically sent by the HP-85 when the following is typed into the keyboard.

REMOTE 716 (END LINE)

After the END LINE key is pressed, the Model 195A REMOTE and LISTEN indicator lights should come on. If not, check to see that the instrument is set for the proper primary address. Also, check to see that all bus connections are tight.

4.9.2 IFC (Interface Clear)

The IFC command is sent by the controller to set the Model 195A to the talk and listen idle states. The unit will respond to the IFC command by cancelling front panel TALK or LISTEN lights if the intrument was previously placed in one of those modes. IFC also clears device-dependent commands sent without X and clears the output buffer of any processed readings.

To send the IFC command, the controller need only set the IFC line true.

Programming Example—Before demonstrating the IFC command, turn on the front panel REMOTE and TALK indicator lights by entering the following statements into the HP-85 computer:

REMOTE 716 (END LINE)
ENTER 716;A$ (END LINE)

The front panel REMOTE and TALK indicators should now be on. The IFC command may now be sent by entering the following statment into the HP-85:

ABORTIO 7 (END LINE)

After the END LINE key is pressed, the TALK light will turn off, indicating the Model 195A is in the talk idle state.

4.9.3 LLO (Local Lockout)

The LLO command is sent by the controller to remove the Model 195A from the local operating mode. Once the unit receives the LLO command, all its front panel controls (except POWER) will be inoperative.

NOTE

The REN bus line must be true before the instrument will respond to an LLO command.

To lock out the front panel controls of the Model 195A, the controller must perform the following steps:

1. Set ATN true.
2. Send the LLO command to the instrument.

Programming Example—This sequence is automatically performed by the HP-85 when the following statement sequence is typed into the keyboard:

LOCAL LOCKOUT 7 (END LINE)

4.9.4 GTL (Go To Local)

The GTL command is used to take the instrument out of the remote mode. To send the GTL command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 195A to listen.
3. Place the GTL command on the bus.

NOTE

The GTL command does not restore operation of locked out Model 195A front panel controls. With some instruments, however, local control operation may be restored by the GTL command. To restore front panel control operation of the Model 195A, the controller must set the REN line false.

Programming Example—If the instrument is not in the remote and lockout modes, enter the following statements into the HP-85 computer:

REMOTE 716 (END LINE)
LOCAL LOCKOUT 7 (END LINE)

Check to see that the REMOTE indicator is on and that the front panel controls are locked out. The GTL command sequence is automatically sent by the HP-85 with the following statements:

LOCAL 716 (END LINE)

Note that the REMOTE light on the front panel turns off.

Front panel control operation can be restored by setting the REN line false with the following HP-85 statement:

LOCAL 7 (END LINE)

After executing this statement, the front panel controls will again operate.

NOTE
Setting REN false with the LOCAL 7 statement will also take the instrument out of the remote mode.

4.9.5 DCL (Device Clear)

The DCL command may be used to clear the Model 195A, setting it to a known state. Note that all devices on the bus equipped to respond to a DCL will do so simultaneously. When the Model 195A receives a DCL command, it will return to the default conditions listed in Table 4-10.

To send a DCL command, the controller must perform the following steps:

1. Set ATN true.
2. Place the DCL command on the bus.

Table 4-10. Default Conditions (Status Upon Power Up or After SDC or DCL)

Mode	Value	Status
Trigger	T6	Continuous on External
Function	F0	DC Volts
Range	R6	1000V
EOI	K0	Send EOI
Buffer Interval	Q0	Circular Buffer, Disabled
Rate	S2	16.66ms integration period
SRQ	M0	SRQ Disabled
Zero	Z0	Zero Disabled
Delay	W1	Default Delay
Auto Cal	A0	Auto Cal On
Self Test	J0	Cleared on power up.
Data Format	G4	Data sent with prefix; suffix.
Reading Source	B0	A/D Converter
Filter	P3	8 Reading Samples Averaged
Terminator	Y(CR LF)	CR LF

Programming Example—Place the instrument on the 200Ω range with the front panel controls. Also enable the zero and filter modes. Now enter the following statement sequence into the HP-85:

CLEAR 7 (END LINE)

When the END LINE key is pressed, the instrument returns to power-up status.

4.9.6 SDC Selective Device Clear)

The SDC command performs the same function as the DCL command except that only the addressed device responds. This command is useful for clearing only a selected instrument instead of all devices simultaneously.The Model 195A will return to the default conditions listed in Table 4-10 when responding to an SDC command.

To transmit the SDC command, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 195A to listen.
3. Place the SDC command on the data bus.

Programming Example—Using the front panel controls, place the instrument in the 200Ω measurement mode and enable the zero and filter modes. Now enter the following statements into the HP-85:

CLEAR 712 (END LINE)

Note that the instrument did not respond because the SDC command was sent with a primary address of 12. Now enter the following statement into the HP-85 keyboard:

CLEAR 716 (END LINE)

This time the instrument returns to the default conditions listed in Table 4-10.

4.9.7 GET (Group Execute Trigger)

The GET command is sent to the Model 195A to trigger the instrument. Using the GET command is only one of several methods that can be used to trigger readings. More detailed information on all trigger modes, including GET can be found in paragraph 4.10.7.

To send GET command over the bus, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 195A to listen.
3. Place the GET command on the data.

GET can also be sent without addressing by omitting step 2.

Programming Example—Type in the following statements into the HP-85 keyboard:

REMOTE 716 (END LINE)

Place the instrument in the one-shot on GET trigger mode with the following statement:

OUTPUT 716;"T3X" (END LINE)

When the END LINE key is pressed, the decimal point will stop flashing indicating the instrument is waiting for a trigger.

The instrument may be triggered to take a single reading with the following statement:

TRIGGER 716 (END LINE)

The decimal point will flash once, indicating that one reading has been processed.

NOTE
The Model 195A will also respond to GET without addressing. This command is sent with the following HP-85 statement: TRIGGER 7.

The preceding examples use device-dependent commands to place the instrument in the appropriate trigger modes. These commands are covered in detail in paragraph 4.10.

4.9.8 Serial Polling (SPE, SPD)

The serial polling sequence is used to obtain the Model 195A status byte. Usually, the serial polling sequence is used to determine which of several devices has requested service over the SRQ line. However, the serial polling sequence may be used at any time to obtain the status byte from the Model 195A. For more information on status byte format, refer to paragraph 4.10.12.

The serial polling sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The SPE (Serial Poll Enable) command is placed on the bus by the controller.
3. The Model 195A is addressed to talk.
4. The controller sets ATN false.
5. The instrument then places its status byte on the bus to be read by the controller.
6. The controller then sets the ATN line low and places SPD (Serial Poll Disable) on the bus to end the serial polling sequence.

Steps 3 through 5 may be repeated for other instruments on the bus by using the correct talk address for each instrument. ATN must be true when the talk address is transmitted and false when the status byte is read.

Programming Example—The HP-85 SPOLL statement automatically performs the serial polling sequence. To demonstrate serial polling, momentarily power down the Model 195A and enter the following statements into the HP-85 keyboard:

```
REMOTE 716 (END LINE)
S=SPOLL (716) (END LINE)
DISP S (END LINE)
```

When END LINE is pressed the second time, the computer performs the serial polling sequence. When END LINE is pressed the last time, the status byte value is displayed on the CRT. Paragraph 4.10.12 covers the status byte format in detail.

4.10 DEVICE-DEPENDENT COMMAND PROGRAMMING

IEEE device-dependent commands are sent to the Model 195A to control various operating modes such as function, range, zero, filter and data format. Each command is made up of an ASCII alpha character followed by one of more numbers designating specific parameters. For example, a function is programmed by sending an ASCII "F" followed by numbers representing the function. The IEEE bus treats device-dependent commands as data in that ATN is high when the commands are transmitted.

A number of commands may be grouped together in one-string.A command string is terminated by an ASCII "X" character which tells the instrument to execute the command string.

If an illegal command or command parameter is present within a command string, the instrument will:

1. Ignore the entire command string.
2. Display appropriate front panel error messages.
3. Set certain bits in its status byte.
4. Generate an SRQ if programmed to do so.

These programming aspects are covered in paragraphs 4.10.12 and 4.11.

HP-85 examples are included throughout this section to clarify programming.

NOTE

Before performing a programming example, it is recommended that the instrument be set to its default values by sending an SDC over the bus. See paragraph 4.9.6 for information on using the SDC command.

If the HP-85 should become "hung up" at any point, operation may be restored by holding the SHIFT key down and then pressing RESET on the keyboard.

In order to send a device-dependent command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 195A to listen.
3. Set ATN false.
4. Send the command string over the data bus one byte at a time.

Programming Example—Device-dependent commands are sent by the HP-85 using the following statement:

```
OUTPUT 716; A$
```

A$ in this case contains the ASCII characters that form the command string.

NOTE

REN must be true when attempting to program the Model 195A. If REN is false, the instrument will respond with a no remote error message as described in paragraph 4.11.

Commands that affect the Model 195A are listed in Table 4-11. All the commands listed in the Table 4-11 are covered in detail in the following paragraphs.

NOTE

Programming Examples that follow assume that the Model 195A primary address is at its factory setting of 16.

Table 4-11. Device-Dependent Command Summary

Mode	Command	Description				
Function	F0	DC Volts				
	F1	AC Volts				
	F2	Ohms				
	F3	DC Current				
	F4	AC Current				
	F5	Temperature in °F mode				
	F6	Temperature in °C mode				
Range		DCV	Ohms	AMPS	ACV	Temp.
	R0	Auto	Auto	Auto	Auto	
	R1	20mV	20 Ω	20 μA*	200mV	< 230°C
	R2	200mV	200 Ω	200 μA	200mV	> 230°C
	R3	2 V	2 kΩ	2mA	2 V	> 230°C
	R4	20 V	20 kΩ	20mA	20 V	> 230°C
	R5	200 V	200 kΩ	200mA	200 V	> 230°C
	R6	1000 V	2MΩ	2 A	700 V	> 230°C
	R7	1000 V	20MΩ	2 A	700 V	> 230°C
Rate	S0	3.33ms integration; 1 reading sample, 3½ digits averaged.				
	S1	Line cycle integration; 1 reading sample, 4½ digits averaged.				
	S2	Line cycle integration; 2 reading samples, 4½ digits averaged.				
	S3	Line cycle integration; 4 reading samples, 4½ digits averaged.				
	S4	Line cycle integration; 8 reading samples, 4½ digits averaged.				
	S5	Line cycle integration; 16 reading samples, 4½ digits averaged.				
	S6	100ms integration period; 1 reading sample, 5½ digits averaged.				
	S7	100ms integration period; 2 reading samples, 5½ digits averaged.				
	S8	100ms integration period; 4 reading samples, 5½ digits averaged.				
	S9	100ms integration period; 8 reading samples, 5½ digits averaged.				
Zero	Z0	Zero disabled.				
	Z1	Zero enabled.				
Filter	P0	Filter disabled.				
	P1	Front panel filter on.				
	P2	Used with 5½ digit resolution mode.				
	P3	Applied to 20mV, 200mV DC, 20Ω, 200Ω, 2MΩ, 20MΩ, all DCA.				
Trigger	T0	Continuous on talk.				
	T1	One-shot on talk.				
	T2	Continuous on GET.				
	T3	One-shot on GET.				
	T4	Continuous on X.				
	T5	One-shot on X.				
	T6	Continuous on external.				
	T7	One-shot on external.				
EOI	K0	EOI enabled.				
	K1	EOI disabled.				
Multiplex	A0	Multiplex enabled.				
	A1	Multiplex disabled.				
Delay	Wn	n = delay period in ms (0, 2-16,000).				
Status Word	U0	Operating mode status.				
	U1	Number readings stored in buffer.				
	U2	Average of readings in buffer.				
	U3	Lowest reading in buffer.				
	U4	Highest reading in buffer.				
	U5	Calibration value.				

*Not present for AC current.

Table 4-11. Device-Dependent Command Summary (Cont.)

Mode	Command	Description
SRQ Mode	M0	Disabled
	M1	Reading done; overflow.
	M2	IDDC, IDDCO, No remote.
	M4	Buffer full.
	M8	Buffer 1/2 full.
	M16	Self-test failed.
	M32	Trigger overrun
Buffer Rate/Mode	Qmn	m = mode, n = rate. Set fill rate, control buffer recycling mode.
Data Control	B0	Readings from A/D converter.
	B1	Readings from buffer.
Data Format	G0	Readings with prefix/suffix.
	G1	Readings without prefix/suffix.
	G2	Reading with prefixes/suffixes, separated by commas.
	G3	Reading without prefixes/suffixes, separated by commas.
	G4	Reading with prefix, without suffix.
	G5	Readings with prefixes, without suffixes separated by commas.
Digital Calibration	Vn	n represents calibration value
NV Storage	L1	Store constants in non-volatile RAM.
Self Test	J	Test ROM, RAM, display, non-volatile RAM.
Terminator	Y(ASCII)	ASCII character.
	Y(CR LF)	CR LF
	Y(LF CR)	LF CR
	Y(X)	None
Hit Button	Hn	n = number of front panel button.
Display	D	Display ASCII message.
Execute	X	Execute other device-dependent commands.

4.10.1 Execute (X)

The execute command is implemented by sending an ASCII "X" over the bus. Its purpose is to tell the Model 195A to execute other device-dependent commands. Generally, the "X" character is the last byte in the command string. The execute character also controls instrument operation in the T4 and T5 trigger modes as described in paragraph 4.10.7.

NOTE

Command strings sent without an execute character will not be executed at that time, but they will be stored in the command buffer. The next time an execute character is received, the stored commands will be executed, assuming all commands in the previous string were valid.

Programming Example—Enter the following statements into the HP-85 keyboard:

REMOTE 716 (END LINE)
OUTPUT 716; "X" (END LINE)

When the END LINE key is pressed the second time, the front panel listen light turns on, showing that the instrument received the command. No other changes will occur with this example because no other commands were given.

4.10.2 Function (F)

The function commands selects the type of measurement made by the Model 195A. The five parameters associated with the function command set the instrument to measure DCV, resistance, and, with the Model 1950 option installed, ACV, DCA, and ACA. The function may be programmed by sending one of the following commands:

F0 DC Volts
F1 AC Volts
F2 Ohms
F3 DC Current
F4 AC Current
F5 Temperature—°F mode
F6 Temperature—°C mode

Upon power-up, or after the instrument receives a DCL or SDC command, the F0 mode will be enabled.

Programming Example—Place the Model 195A in the DCV function from the front panel and enter the following statements into the HP-85 keyboard:

REMOTE 716 (END LINE)
OUTPUT 716; "F2X" (END LINE)

After the END LINE key is pressed the second time, the Model 195A will change to the ohms function as shown by the OHMS indicator light.

Programming Example—To program the instrument for temperature measurements in °C, enter the following statements into the HP-85:

REMOTE 716 (END LINE)
OUTPUT 716; "F6X" (END LINE)

When the END LINE is pressed the second time, the instrument will enter the °C temperature mode.

4.10.3 Range (R)

The range command gives the user control over the sensitivity of the instrument. Range command parameters are summarized in Table 4-12. Note that R7 is a range unique the ohms function; both R6 and R7 set the instrument to the same range on the remaining measuring functions.

Upon power-up, or after receiving a DCL or SDC, the instrument will be in the R6 mode.

Programming Example—Select the autorange mode with the front panel AUTO button. Enter the following statements into the HP-85:

REMOTE 716 (END LINE)
OUTPUT 716; "R6X" (END LINE)

When END LINE is pressed the second time, the autorange mode is cancelled, and the instrument switches to the R6 range.

4.10.4 Rate (S)

The rate command controls the following Model 195A parameters:

1. The integration period.
2. The number of readings averaged.
3. Usable resolution.

These parameters are summarized in Table 4-13, which also lists the rate command for each combination. The default value for the rate command is S2 corresponding to a 16.66ms integration period (at 60Hz) with two readings averaged. The instrument will be in the S2 mode upon power-up or after receiving a DCL or SDC command. In temperature, S1 is the default rate mode from the front panel.

NOTES
1. Table 4-13 lists usable resolution; the bus always returns to 5½ digits.

Table 4-12. Range Commands

Range Command	Full Range Value				
	DCV	OHMS	AMPS (AC & DC)	ACV	Temp
R0	Auto	Auto	Auto	Auto	—
R1	20mV	20 Ω	20 μA*	200mV	< 230°C
R2	200mV	200 Ω	200 μA	200mV	> 230°C
R3	2 V	2 kΩ	2mA	2 V	> 230°C
R4	20 V	20 kΩ	20mA	20 V	> 230°C
R5	200 V	200 kΩ	200mA	200 V	> 230°C
R6	1000 V	2MΩ	2 A	700 V	> 230°C
R7	1000 V	20MΩ	2 A	700 V	> 230°C

*Not on ACA function.

Table 4-13. Rate Commands

Command	Integration Period (mS)	Usable Resolution	Number Reading Samples Averaged
S0	3.33	3½	1
S1	16.66*	4½	1
S2	16.66*	4½	2
S3	16.66*	4½	4
S4	16.66*	4½	8
S5	16.66*	4½	16
S6	100	5½	1
S7	100	5½	2
S8	100	5½	4
S9	100	5½	8

*At 60Hz. Period is 20ms at 50Hz.

2. The programmed line frequency affects the integration period in the S1 through S5 modes. Make sure the instrument is programmed for the correct power line frequency as described in paragraph 3.5.5. Operating the Model 195A with the incorrect line frequency will result in noisier readings.

Programming Example—Enter the following statement sequence into the HP-85 keyboard:

REMOTE 716 (END LINE)
OUTPUT 716; "S0X" (END LINE)

When the END LINE key is pressed the second time, the instrument changes to the S0 mode.

4.10.5 Zero Command (Z)

The zero mode serves as a means for a baseline suppression. When the correct zero command is sent over the bus, the instrument will enter the zero mode, as indicated by the front panel ZERO indicator light. All readings displayed or sent over the bus while zero is enabled are the difference between the stored baseline and the actual voltage level. For example, if a 100mV baseline is stored, 100mV will be subtracted from all subsequent readings as long as the zero mode in enabled. The value of the stored baseline can be a little as a few microvolts or as large as the selected range will permit. The zero mode is controlled by sending one of the following commands over the bus:

Z0 Zero Disabled
Z1 Zero Enabled

Upon power-up, or after a DCL or SDC, Z0 is selected.

Programming Example—With the front panel ZERO button, disable the zero mode and enter the following statements into the HP-85 keyboard:

REMOTE 716 (END LINE)
OUTPUT 716; "Z1X" (END LINE)

After the END LINE key is pressed the second time, the front panel ZERO indicator light will turn on.

NOTES:

1. Setting the range lower than the stored baseline will cause an overflow, as indicated by the front panel "OFLO" message. The overflow condition will also affect the status byte as described in paragraph 4.10.12.
2. Enabling zero reduces the dynamic range of the measurement. For example, with the instrument on the 2VDC range and a stored baseline of +1.0000VDC, an input voltage of +2.0000VDC will still overload the A/D converter, even though the display shows only +1.0000VDC.
3. Once zero is enabled, the baseline will be stored when the next A/D conversion is triggered. Zeroed readings will then be displayed with each subsequent triggered conversion. For example, if the Model 195A is placed in one of the one-shot trigger modes, the first trigger following the zero enable command will store the baseline. All remaining triggers received while the zero is enabled will trigger zeroed readings with the previously stored baseline subtracted from the actual signal level.
4. To store a new baseline, send the Z1 command. The new baseline will then be stored with the first triggered conversion as previously described.
5. A separate baseline can be stored for each measuring function. For example, 10VDC could be stored for DC voltage measurements, 15VAC for AC voltage measurements, 50Ω for resistance measurements, 2mA for DC current measurements, and 50mA for AC current measurements.

4.10.6 Filter (P)

The filter command controls the type of filtering applied to the input signal. The Model 195A filters the signal by taking the average of a number of successive readings. Since noise is mostly random in nature, it can be largely cancelled out with this method. Table 4-14 lists the Model 195A filter commands along with equivalent front panel operating modes that automatically select the corresponding filter. Note that the P0 mode is not available from the front panel. Upon power-up or after a DCL or SDC command, the instrument will assume a filter mode consistent with other operating parameters.

Programming Example—Check to see that the front panel FILTER light is out and then enter the following statements into the HP-85:

REMOTE 716 (END LINE)
OUTPUT 716; "P1X" (END LINE)

When the END LINE key is pressed the second time, the front panel FILTER light will turn on, indicating that the P1 filter mode is enabled.

Table 4-14. Filter Commands

Command	Front Panel Equivalent Mode	Reading Samples Averaged
P0	No averaging.*	1
P1	Same as Front Panel FILTER On.	64
P2	5½ Digits, FILTER Off	32
P3	Used on 20mV, 200mV DC, 20Ω, 200Ω, 2MΩ, 20MΩ, all DCA.	8

*Not available from front panel.

4.10.7 Triggering (T)

Triggering provides a stimulus to begin a reading conversion within the instrument. Triggering may be done in two basic ways: in a continuous mode, a single trigger command is usedto start a continuous series of readings; in a one-shot trigger mode, a separate trigger stimulus is required to start each conversion.

The Model 195A has eight trigger commands as follows:

T0 Continuous On Talk
T1 One-shot On Talk
T2 Continuous On GET
T3 One-shot On GET
T4 Continuous On X
T5 One-shot On X
T6 Continuous On External Trigger
T7 One-shot On External Trigger

Upon power-up or after a DCL or SDC command, the T6 mode is enabled.

In the T0 and T1 modes, triggering is done by addressing the Model 195A to talk. In the T2 and T3 modes, a GET command provides the trigger stimulus. In the T4 and T5 modes, the execute (X) character triggers the instrument, while a trigger applied through the rear panel EXTERNAL TRIGGER input or operation of the front panel TRIG button provides the necessary trigger stimulus in the T6 and T7 modes.

NOTES:

1. The Model 195A may be toggled between any of the continuous trigger modes and the corresponding one-shot mode with the following front panel control sequence: PRGM; 9.
2. A LLO command will inhibit front panel triggering in the T6 and T7 modes; however, external triggering will not be affected by the LLO command.
3. If EXT TRIGGER is connected to VOLTMETER COMPLETE in the T7 mode, the trigger pulse aborts the new reading immediately after it is complete. As a result, the IEEE bus never gets the new reading, although it will appear on the front panel display. If this mode of operation is desired, place the buffer in the Q11B1 mode (see paragraph 4.10.13); in this mode, the instrument can transmit IEEE information when ready.

Programming Example—Place the instrument in the one-shot on talk mode with the following HP-85 statement sequence:

REMOTE 716 (END LINE)
OUTPUT 716; "T1X" (END LINE)

After the END LINE key is pressed the second time, the instrument will be in the one-shot on talk trigger mode. The display decimal point will stop flashing, indicating the instrument is waiting for a trigger.

Trigger the instrument with a talk command by entering the following statement into the HP-85:

ENTER 716; A$ (END LINE)

Note that the decimal point flashes once, indicating that one reading has been processed. To continue taking readings in this mode, one talk command must be sent for each conversion.

4.10.8 EOI (K)

The EOI line on the bus is usually set low by a device during the last byte of its data transfer sequence. In this way, the last byte is properly identified, allowing variable length data words to be transmitted. The Model 195A will normally send EOI during the last byte of ts data string or status word. The EOI response of the instrument may be sent with one of the following commands:

K0 Send EOI during last byte.
K1 Send no EOI.

Upon power-up, the K0 mode is enabled.

Programming Example—Model 195A EOI response will be suppressed with the following HP-85 statement sequence:

REMOTE 716 (END LINE)
OUTPUT 716 "K1X" (END LINE)

Note that the HP-85 does not normally rely on EOI to mark the last byte of data transfer. Some controllers, however, may require that EOI be present at the end of transmitting.

4.10.9 Multiplex (A)

The Model 195A has built-in multiplex routines that automatically calibrate and zero the instrument, maintaining its high accuracy. The multiplex routines can be defeated, either through front panel Program 2 (paragraph 3.5.3), or through one of the following commands:

A0 Enable multiplex routines.
A1 Disable multiplex routines.

Upon power-up, or after a DCL or SDC, the A1 mode is enabled.

The multiplex routines may be disabled in situations requiring very high impedance measurements.

Programming Example—Enter the following statements into the HP-85:

REMOTE 716 (END LINE)
OUTPUT 716; "A1X" (END LINE)

When the END LINE key is pressed the second time, the multiplexer routines are disabled.

4.10.10 Delay (W)

The delay command controls the time interval that occurs from the point the instrument is triggered until it begins integration of the input signal. This feature is useful in situations where a specific time period must transpire to allow an input signal to settle before measurement. During the delay period, the input multiplexing FETs are switched on so the instrument is set to begin integration upon conclusion of the programmed delay period, which may be programmed with the following command:

Wn

Here, n represents the delay value in milliseconds for values of 2 or greater. The allowable range for the delay period parameter is between 0 (minimum) and 16,000 in 1ms steps. The following is a list of commands and the resulting delay periods:

W0 < 2ms
W1 Default (6.5ms for all except 20MΩ range which is 50ms).
W2-16,000 Programmed value

Upon power-up, or receiving a DCL or SDC command, the delay period is set to defult (W1). The selected defaults are chosen to give the correct reading when a trigger is given.

Programming Example—To program a 250ms delay period into the instrument, enter the following statements into the HP-85 keyboard:

REMOTE 716 (END LINE)
OUTPUT 716; "W250X" (END LINE)

After the END LINE key is pressed, the instrument will wait for 250ms after each triggered conversion until the start of each conversion period.

4.10.11 Status Word (U)

The status word commands allow access to information concerning present operating modes of the instrument as well as buffer and digital calibration parameters. When the status word command is given, the Model 195A will transmit appropriate status inforamtion instead of its normal data string the next time it is addressed to talk. Model 195A status word commands include:

U0 Send normal instrument status on operating modes such as range, function, etc.
U1 Send the number of readings logged in 100 point buffer.
U2 Send the average of the readings in the 100 point buffer.
U3 Send the lowest reading currently in the 100 point buffer.
U4 Send the highest reading currently stored in the 100 point buffer.
U5 Send the present assumed calibration value.

Table 4-15 shows the general format for each of the six commands. The letters in the U0 format correspond to other device-dependent commands, such as Range (R), Function (F), etc.

NOTES:

1. Status word information will be returned only once each time the command is sent. Once status is read, the instrument will send its normal data string the next time it is addressed to talk.
2. Buffer rate and mode (Q), and delay (W) status are each two bytes in length. The remaining status parameters in the U0 status word are each one byte in length.
3. To make sure the correct status is returned, the status word should be read immediately after sending the command, or incorrect status may be transmitted.
4. The self-test (J) byte is set to 2 after passing the self-test (J) command and 1 if the test fails. This byte will be set to zero upon power-up.
5. The returned terminator character (Y) is derived by ANDing the byte with 00001111 and then ORing the result with 00110000. For example, the last byte in the normal (CR LF) terminator sequence is a LF or ASCII 10 (00001010). ANDing with 00001111 yields 00001010. ORing with 00110000 gives 00111010 which is printed out as an ASCII colon (:). This occurs with any byte $20 or smaller.
6. The status word should not be confused with the status byte. The status word contains a number of bytes pertaining to the various operating modes of the instrument. The status byte is a single byte that is read with the SPE, SPD command sequence and contains information on SRQ status and error and data conditions.
7. The returned U5 value will depend on the selected range and function.
8. The returned delay (W) status does not print out in numeric ASCII form; the exact characters printed will depend on controller configuration. For a delay of 0ms, however, the returned value will be 00.
9. The returned SRQ mode (M) values are determined by adding up the values of the bit positions in the status byte that could cause an SRQ according to the previously programmed value of the SRQ mode (see examples below). (See paragraph 4.10.12 for complete information on the SRQ mask and status byte.)
10. The instrument shoud be in the B1 mode (paragraph 4.10.13) to read U3 and U4 status buffer numbers.

Table 4-15. Status Word Formats

Command	Format*	Meaning
U0	195A< space > TFRKQQSMZWWAJGBPYY (CR LF)	Instrument operating modes.
U1	SIZE +nnn (CR LF)	Number readings stored in buffer.
U2	AVG±1.23456E ± 0 (CR LF)	Average of readings in buffer.
U3	LO±1.23456E±0,B000 (CR LF)	Lowest reading in buffer.
U4	HI±1.23456E±0,B000 (CR LF)	Highest reading in buffer.
U5	CAL±1.23456E±0 (CR LF)	Assumed calibration value.

*CR LF is normal terminator.

11. If the multiplex mode is turned off with the A1 bus command, a 1 will appear in the A byte in the U0 status word. If the multiplex mode is turned off with front panel Program 2, the A byte will have a value of 7.

SRQ Command Value	Status Word M Byte Values
M0	0
M1	1
M2	2
M4	4
M8	8
M32	(space)
M33	

Programming Example—Enter the program below into the HP-85. Be sure to include line numbers.

PROGRAM	COMMENTS
10 REMOTE 716	Set up instrument for remote operation.
20 DIM A$[25]	Dimensions A$ for 25 characters.
30 OUTPUT 716; "U0X"	Send U0 status command.
40 ENTER 716; A$	Enter status word into computer.
50 DISP "TFRKQQSMZWWA-JGBPYY"	
60 DISP A$	Display on CRT.
70 END	

After entering the program, press the HP-85 RUN key. The U0 status word will then be displayed on the CRT.

4.10.12 SRQ Mode (M) and Status Byte Format

The SRQ command controls which of a number of conditions within the Model 195A will cause the instrument to request service from the controller with the SRQ command. Once an SRQ is generated, the Model 195A status byte can be-checkedto determine if it was the Model 195A that requested service. Other bits in the status byte could also be set depending on certain data or error conditions.

The Model 195 can be programmed to generate an SRQ under one or more of the following conditions:

1. If a reading has been completed.
2. If an overflow condition occurs.
3. If an Illegal Device-Dependent Command Option (IDDCO) is received.
4. If the instrument is not in remote when a command is sent.
5. When the 100 point buffer is either half full or completely full.
6. If an attempt is made to trigger the instrument while it is still processing a reading due to a previous trigger.

Upon power-up or after a DCL or SDC command, SRQ is disabled.

SRQ Mask—In order to facilitate SRQ programming, the Model 195A uses an internal mask to generate an SRQ. When a particular mask bit is set, the Model 195A will send an SRQ when those conditions occur. Bits within the mask can be controlled by sending the ASCII letter "M" followed by a decimal number to set the appropriate bits. Table 4-16 lists the commands to set the various mask bits, while Figure 4-10(a) shows the general mask format.

Table 4-16. SRQ Mask Commands

Command	Sets Bit Number	Conditions to Generate SRQ
M1	B0 (LSB)	Reading Done; Overflow
M2	B1	IDDC, IDDCO, or No remote.
M4	B2	Buffer full
M8	B3	Buffer 1/2 full
M16	B4	Self-test failed
M32	B5	Trigger Overrun

Status Byte Format—The status byte contains information relating to data and error conditions within the instrument. When a particular bit is set, certain conditions are present. Table 4-17 lists the meanings of the various bits, and Figure 4-10(b) shows the general format of the status byte, which is obtained by using the SPE, SPD polling sequence described in paragraph 4.9.8.

Bit 6 in the status byte is the SRQ bit. If this bit is set, the SRQ was generated by the Model 195A. Bit 5 is the error bit; the meaning of bits 0 through 4 is determined by the condition of bit 5. If bit 5 is set, the error conditions in Table 4-17 apply; if bit 5 is cleared the data conditions apply.

The various bits in the status byte are described below:

1. Reading Overflow—Set when an overrange input is applied to the instrument.
2. Buffer Full—Set when no more buffer locations are available. This bit will be cleared when at least one buffer location is available.
3. Buffer One-Half Full—This bit will be set if at least one-half of the 100 point buffer is full; it will be cleared when less than half the buffer storage capacity is taken up.
4. Reading Done—Set when the instrument has complete the present conversion and is ready to take another reading.
5. Busy—The instrument is still executing a prior command and is not yet ready to accept a new command.
6. IDDCO—An illegal command option such as K5 has been sent. This bit is cleared when the status byte is read.
7. IDDC—An illegal command will set this bit. For example, N1 is illegal since no such letter exists in the command set. The IDDC bit will be cleared on a reading of the status byte.
8. Trigger Overrun—Set when a triggered reading is received while still processing a previously triggered reading.

NOTES:

1. Once the Model 195A has generated an SRQ, its status byte should be read to clear the SRQ line. Otherwise the instrument will continuously assert SRQ.
2. The Model 195A may be programmed to generate an SRQ for more than one condition simultaneously. For example, to set SRQ mask bits for an SRQ if the buffer is full and when an overflow occurs, the following command would be sent: M5X.
3. The SRQ mode can also be programmed with a string of eight binary digits. For example, M 00001100X sets the instrument for SRQ on buffer one-half full or buffer full.
4. If the unit is programmed to generate an SRQ when a reading is done, it will generate the SRQ only when reading is complete; the SRQ may be cleared by reading the status byte. The reading done bit in the status byte may then be cleared by requesting a normal reading from the instrument.

Programming Example—Enter the following program into the HP-85:

PROGRAM	COMMENTS
10 REMOTE 716	Set up for remote operation.
20 OUTPUT 716; "M2X"	Program for SRQ on IDDC or IDDCO.
30 OUTPUT 716; "K5X"	Attempt to program illegal command option.
40 S=SPOLL (716)	Perform serial poll.
50 DISP "B7 B6 B5 B4 B3 B2 B1 B0"	
60 FOR I=7 TO 0 STEP -1	Loop eight times.
70 DISP BIT (S,I);	
80 NEXT I	
90 DISP	
100 END	

Press the HP-85 RUN key. The computer conducts a serial poll and displays the status byte bits in order on the CRT. The SRQ (B6), error (B5), and IDDCO (B0) bits are set because line 40 of the program attempted to program the instrument with an illegal command option (K5).

Table 4-17. Status Byte Interpretation

Bit	Bit 5=0 (Data Conditions)	Bit 5=1 (Error Conditions)
0 (LSB)	Overflow	IDDCO
1	Buffer full	IDDC
2	Buffer 1/2 full	No remote
3	Reading done	Trigger overrun
4	Busy	Failed Self test

4.10.13 Buffer Commands (Q and B)

The Model 195A has an internal 100 point buffer that is useful for storing a series of readings. Through the two buffer commands, the user has IEEE bus control over the following aspects of buffer operation:

1. Enabling or disabling buffer operation.
2. Controlling the rate at which the buffer fills.
3. Whether buffer storage ceases when the buffer is full or recycles, overwriting old data.
4. Whether reading data comes from the A/D converter or one of the buffer locations.

The Q command controls the rate and mode buffer and is of the form Qmn. Here m represents one of the buffer modes as follows:

m=0 Fill buffer and stop filling. Buffer emptied with a Q0.

m=1 Fill buffer and stop, but continue when a buffer cell is available. A cell becomes available when data is read from it.

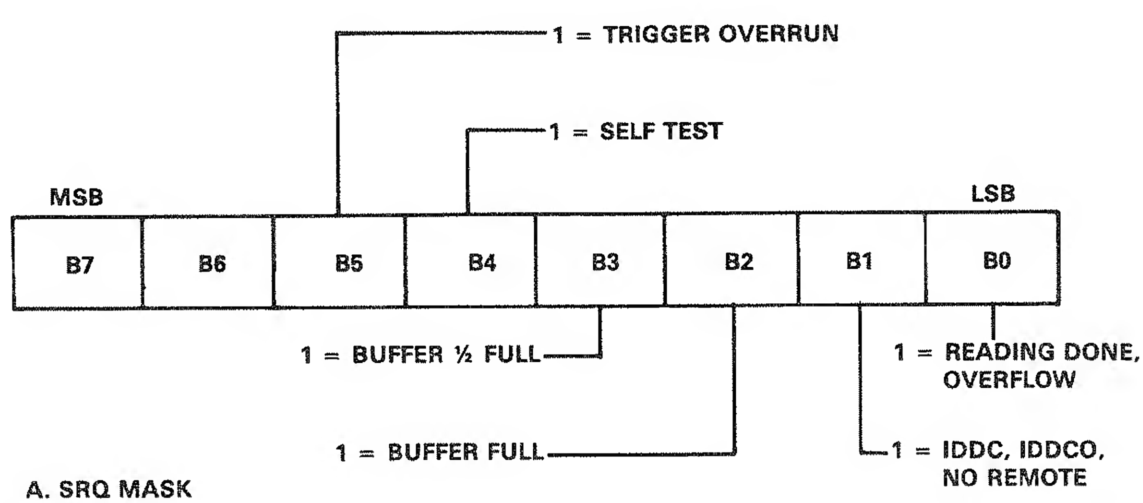
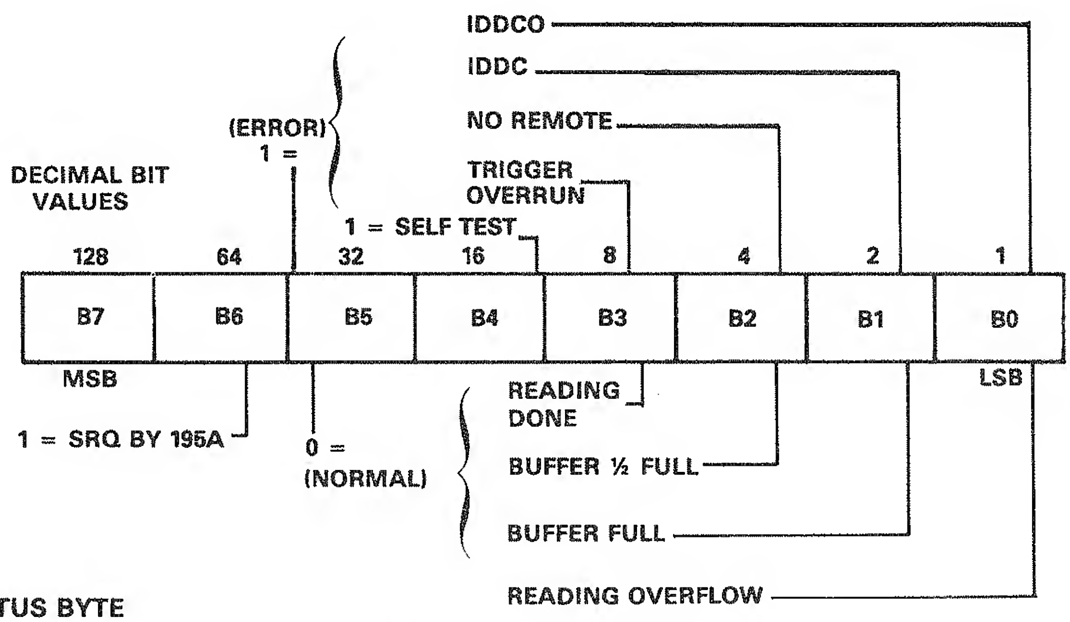


Figure 4-10. SRQ Mask and Status Byte Formats



B. STATUS BYTE

Figure 4-10. SRQ Formats (Cont.)

The n parameter in the Q command sets the fill rate as summarized in Table 4-18. Note that if n=0, buffer operation is disabled. The second command associated with buffer operation is the B command, which is described as follows:

B0 Bus readings come from the A/D converter regardless of buffer operation.

B1 Bus readings come from the oldest buffer location. As each reading is requested, the read buffer pointer is incremented to obtain successive readings. In Q0n, all locations can be read non distructively in a circular fashion whether locations are all used or not.

Upon power-up or after a DCL or SDC, the instrument will be in the B0 mode.

Examples:

Q00X Disables buffer completely.

Q01X Buffer will fill at conversion rate and then stop when full.

Q25X Buffer will fill at one minute intervals. When buffer is full, oldest data will be overwritten.

B0X Reading transmitted over the bus will come directly from the A/D converter.

B1X Readings sent over the bus will come from the buffer location indicated by the read pointer.

NOTES:

1. Buffer operation can also be controlled from the front panel as described in paragraph 3.5.8.
2. The Model 195A can be programmed to generate an SRQ when the buffer is one-half or completely full. See paragraph 4.10.12.
3. A Q0 command also sets the instrument to the B0 mode.

Programming Example—Enter the following program into the HP-85:

PROGRAM	COMMENTS
10 DIM A$ [20]	Dimension A$.
20 REMOTE 716	Set up for remote operation.
30 OUTPUT 716; "Q0X"	Clear buffer.
40 OUTPUT 716; "Q01X"	Enable buffer at fastest rate.
50 S = SPOLL (716)	Obtain status byte
60 IF BIT (S,1)=0 THEN 50	Buffer full yet?
70 OUTPUT 716; "B1X"	Switch so that data comes from buffer.
80 FOR I=1 TO 100	Loop 100 times.
90 ENTER 716; A$	Enter reading into computer.
100 DISP I;A$	Display on CRT.
110 NEXT I	
120 END	

After entering the program, press the HP-85 RUN key. The program will enable the buffer. After all 100 readings are stored, the computer requests and displays the 100 buffer readings on the CRT.

Table 4-18. Buffer Rate Command Parameters

Command (Qmn) n=	Rate
0	Clear buffer
1	Conversion rate
2	1 second intervals
3	5 second intervals
4	10 second intervals
5	1 minute intervals
6	5 minute intervals
7	10 minute intervals
8	30 minute intervals
9	1 hour intervals

4.10.14 Data Format (G)

Volts, Resistance and Current

Through the use of the G command, the format of the data transmitted over the IEEE bus can be controlled as follows:

G0 Single reading including prefix and suffix. Example NDCV+1.23456E-2 (Bnnn follows reading for B1 mode) [terminator].

G1 Single readings suppress prefix or suffix. Example: +1.23456E-2 [terminator].

G2 Transmit complete buffer with prefixes and suffixes. Commas separate the individual buffer readings. Example: NDCV+1.23456E-2,B001,NDCV-1.06789E+2, B002...NDCV 1.2356E-2, B100 [terminator].

G3 Transmit complete buffer without prefixes and suffixes Commas separate the individual readings. Example: +1.23456E-2,+1.06786E+2...1.23456E-2 [terminator].

G4 Single reading with prefix without buffer suffix regardless of B mode.

G5 Buffer readings with prefix without buffer suffix.

Upon power-up, or after receiving a DCL or SDC, the instrument will be in the G4 mode.

Figure 4-11 further clarifies the meanings of prefixes and suffixes. Note that the prefix defines a normal or overflow reading as well as the measuring function.

NOTES:

1. The B command affects the source of the data. In the B0 mode, the bus data will come from the A/D converter. In the B1 mode data comes from the buffer.
2. The G2 and G3 modes, if output is from the A/D converter (B0) no terminator will be sent.
3. The mantissa of data transmitted over the bus is always 5½ digits regardless of the selected display resolution. The usable resolution depends onthe selected S mode.
4. Programmed terminator and EOI sequences appear at the end of each reading in the G0, G1 and G4 modes, but are transmitted only at the end of the buffer in the G2, G3 and G5 modes. No terminator is sent if in G2 or G3 modes while in B0 (data from A/D).
5. The position of the decimal point and exponent depends on the selected range.

Programming Example—Enter the program below into the HP-85:

PROGRAM	COMMENTS
5 DIM A$ [2200]	Dimension A$
10 REMOTE 716	Set up for remote operation.
20 OUTPUT 716; "Q0X"	Clear Buffer.
30 OUTPUT 716; "Q01X"	Enable Buffer
40 S=SPOLL (716)	
50 IF BIT (S,1)=0 THEN 50	Buffer full?
60 OUTPUT 716; "B1X"	Set data to come from buffer.
70 For I=0 TO 3	Loop four times.
80 OUTPUT 716; "G";I;"X"	Set data format.
90 ENTER 716; A$	Request data string.
100 DISP A$	Display data string.
110 NEXT I	
120 END	

After entering the program, press the HP-85 RUN key. The instrument is programmed to store readings in its buffer. The data format is set to each of the four modes, and data is requested and displayed in each mode on the CRT. Note that a number of seconds pass in the G2 and G3 modes since the instrument must first assemble the entire buffer before transmitting it to the computer.

Temperature

Temperature data sent over the IEEE bus has a format similar to other instrument data. Formats for the two temperature modes are:

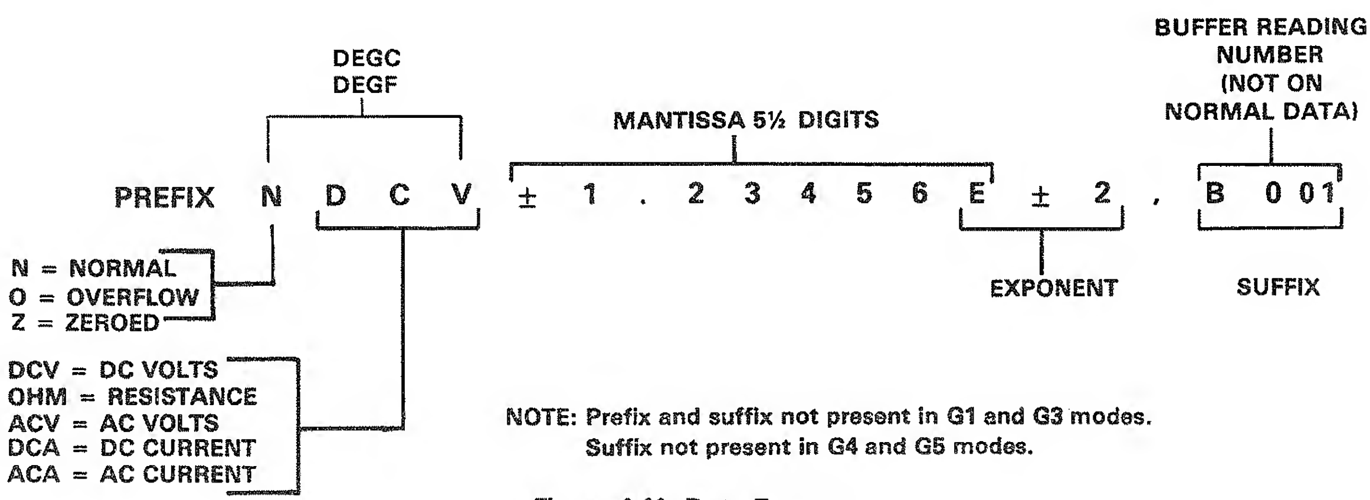


Figure 4-11. Data Format

DEGFnnnn.nnE+n°F Mode
DEGCnnnn.nnE+n°C Mode

NOTES

1. The data prefix is not present in the G1, G3 or G5 data modes.
2. The bus reading rate may be increased by sending the following command string: S1P0X. However, noisier readings will result.
3. Turning the multiplex mode off withthe A1 command will also increase the reading rate, but probe heating may increase, possibly affecting accuracy.

Programming Example—Connect a suitable probe to the instrument and enter the following statements into the HP-85 keyboard:

```
REMOTE 716 (END LINE)
OUTPUT 716; "F5X" (END LINE)
ENTER 716; A$ (END LINE)
DISP A$ (END LINE)
```

After the last statement is executed, the temperature data string will be displayed on the CRT.

4.10.15 Digital Calibration (V)

Volts, Resistance and Current

The digital calibration command performs the same operation as front panel Program 5. Through the use of this command, a calibration value can be transmitted to the instrument. Once the calibration value is stored, the MPU can then check the calibration value against the measured signal to maintain instrument accuracy.

The calibration command is of the form Vnnnnnn, where n represents a numeric digit.

NOTES:

1. The decimal point and exponent are automatically set according to the selected range; these parameters will be ignored and should not be entered into the calibration command parameter.
2. Once the calibration value is stored, NV storage must be performed, with Program 1.
3. Only as many significant digits as necessary need to be entered. For example, for calibration of the 20V range with a 19.000V input value, the following command would be used: V19X.
4. The correct calibration value must be connected to the instrument before the V command is sent. See Section 7 for the complete calibration procedure.
5. The PRGM light will flash until NVRAM storage is performed successfully.

Programming Example—Using the front panel controls, place the instrument in the 2VDC mode. Connect a precise 1.9VDC calibration voltage to the input terminals and enter the following statements into the HP-85.

```
REMOTE 716 (END LINE)
OUTPUT 716; "V19X" (END LINE)
```

When END LINE is pressed the second time, the instrument will calibrate itself in accordance with the applied signal.

After the instrument receives the V command, two internal readings may be obtained from the unit by addressing it to talk in the normal manner, regardless of the trigger mode. The first reading is the old calibration signal, which has a value determined by the old calibration constants. Once this reading is obtained, the calibration signal may be removed, if desired. Note that this reading must be requested before calibration is completed, or it will be overwritten by the second reading.

The second reading takes into account the new calibration constants, but it is not used to perform calibration. Two volt AC calibration includes a third step, since a second calibration value must be applied (the second is 1/10 the first). As a result, 2VAC calibration will cause three internal readings to be triggered.

Programming Example—Enter the program below into the HP-85:

PROGRAM	COMMENTS
OUTPUT 716; "T1F1R3V1.0000X"	Program for one-shot on talk, 2VAC range, first calibration value.
ENTER 716; A$	Enter first reading with old calibration constants.
DISP A$	Displa reading on CRT.
OUTPUT 716; "V0.10000X"	Program second calibration value.
ENTER 716; A$	Enter second reading with old constant.
DISP A$	Display second reading.
ENTER 716; A$	Enter third reading (reading is now newly calibrated).
DISP A$	Display third reading.

Temperature

The Model 195A temperature calibration sequence may be performed by sending commands over the IEEE bus with one of two methods.

1. Emulate the front panel control sequence with the H (hit button) command. (H10X, H5X, H0X, etc.)
2. Use the V command along with the calibration parameters after the instrument is in the temperature mode. For example, the following command string might be used: V0.00385X V1.49436X V100.00X V1X V4X Note that it is not necessary to enter Program 5 before calibrating the instrument with the V command.

Programming Example—Enter the following program into the HP-85 keyboard; be sure to press the END LINE key after each statement.

PROGRAM	COMMENTS
10 REMOTE 716	Set up 195A for remote operation.
20 CLEAR 716	Return 195A to default conditions.
30 OUTPUT 716;"F6X"	Program for °C temperature mode.
40 OUTPUT 716;"V0.00392X"	Program alpha value.
50 OUTPUT 716;"V1.49633X"	Program delat value.
60 OUTPUT 716;"V101.00X"	Program probe resistance at 0°C.
70 OUTPUT 716;"V2X"	Program for NBS standard.
80 OUTPUT 716;"V3X"	Program for 3-wire operation.
90 END	

After entering the program, press the HP-85 RUN key. As each parameter is sent to the Model 195A, the value will appear on the display. Once all parameters have been programmed, the instrument will display the usual "CAL" message and then return to the normal temperature mode.

4.10.16 Non-Volatile Memory Storage (L)

The Model 195A uses a non-volatile (NV) RAM to store the IEEE primary address, line frequency, calibration constants, and Model 1950 option status. Once the correct parameters are entered into the machine, NVRAM storage can be done either with front panel Program 1, or with the L command. To perform NVRAM storage from the IEEE bus, the following command is sent: L1X. NV storage will take place when the instrument receives this command sequence.

NOTE

NVRAM storage may be disabled by removing a calibration jumper. See paragraph 7.5.10 for details.

Programming Example:

NOTE

Do not perform these steps unless actual NV storage is desired. Unless proper calibrating parameters have been previously programmed, inadvertently using this command could seriously affect instrument accuracy.

REMOTE 716 (END LINE)
OUTPUT 716; "L1X" (END LINE)

When the END LINE key is pressed the second time, NV storage takes place.

4.10.17 Self-Test (J)

The J command causes the instrument to perform the same tests it automatically performs upon power-up. When the self-test command is given, the Model 195A performs the following tests:

1. NVRAM Test
2. RAM Test
3. ROM Test
4. A/D Converter Test

J command parameters include:

J0 Clear J byte in U0 status word.
J1 Perform self-test.

If the self-test is successful, the J byte in the U0 status word will be set to 2. Otherwise this byte will be set to 1. Also, the following message will be shown on the display if the instrument passes the tests:

PASS

Programming Example—Enter the following statements into the HP-85:

REMOTE 716 (END LINE)
OUTPUT 716; "J1X" (END LINE)

When the END LINE key is pressed the second time, the instrument performs the self-test. If successful, the PASS message will be displayed and the self test (J) byte in the U0 status word will be set to 2. This byte may be cleared with the following statement:

OUTPUT 716; "J0X" (END LINE)

4.10.18 Programmable Terminator (Y)

The Model 195A uses special terminator characters to mark the end of its data string or status word. To allow a wide variety of controllers to be used, the terminator can be changed by sending the appropriate command over the bus. The default value is the commonly used carriage return, line feed (CR LF) sequence. The terminator sequence will assume this default value upon power-up.

The terminator may be programmed by sending the ASCII character Y followed by the desired terminator character. Any ASCII character except one of the following may be used:

1. Any capital letter.
2. Any number.
3. Blank
4. + - / , . or e

Special command characters will program the instrument for special terminator sequences as follows:

1. Y(LF)(CR)X=(LF CR) (two terminators)
2. Y(CR)(LF)X=(CR LF) (two terminators)
3. Y(LF)X=(LF) (one terminator)
4. YX=no terminator

NOTE

Most controllers use the CR or LF character to terminate their input sequences. Using a non-standard terminator may cause the controller to hang up unless special programming is used.

Programming Example—The terminator can be eliminated by sending an YX with the following HP-85 statements:

REMOTE 716 (END LINE)
OUTPUT 716; "YX" (END LINE)

When END LINE is pressed the second time, the terminator is suppressed; no terminator will be sent by the instrument when data is requested. The absence of the normal terminator may be verified by entering the following statement into the HP-85 keyboard.

ENTER 716; A$ (END LINE)

At this point, the HP-85 ceases to operate because it is waiting for the standard CR LF terminator sequence to terminate the ENTER statement. The computer may be reset by holding down the SHIFT key and then pressing RESET on the keyboard. To return the instrument to the normal terminator sequence, enter the following statement into the HP-85:

OUTPUT 716; "Y";CHR$ (13);
CHR$(10); "X" (END LINE)

4.10.19 Hit Button (H)

The hit button command allows the user to emulate virtually any front panel control sequence. Through the use of the H command, the front panel programs may be entered through commands given over the bus. Also, digital calibration voltages can be transmitted.

The H command is sent by sending the ASCII letter followed by a number representing a front panel control. These control numbers are shown in Figure 4-12.

Examples:
H3X Toggles the instrument's autorange mode.
H10XH5X Enters front panel Program 5.

Programming Example—Enter the following statements into the HP-85:

REMOTE 716 (END LINE)
OUTPUT 716; "H0X" (END LINE)

When the END LINE is pressed the second time, the instrument is placed in the OHMS mode.

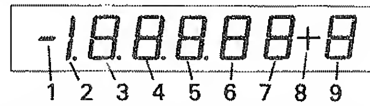
4.10.20 Display (D)

The display commands control ASCII messages that can be placed into the Model 195A display. Naturally, the letters that can be displayed are limited by the capabilities of the 7 segment readouts, but, even with those limitations, considerable versatility is possible. Messages may be controlled with the following commands:

DaaaaaaX—The command letter is D while a represents a printable ASCII character (up to 10 characters may be sent).
DX—The DX command restores the display to normal operation.

NOTES:

For the following notes, refer to the display numbering sequence shown below.



1. The character in the first position above must be a minus (-) sign or it will be ignored.
2. The second character must be a 1 decimal point.
3. Display positions 3 through 7 and 9 will accept any displayable ASCII character. Any undisplayable characters will appear as a "d" segment. A "d" segment is indicated below.


"d" segment

4. Decimal points are set on the current display position, if possible, and do not advance the display to the next position.
5. Display position 8 can be only a + or -. If any other character is sent for that position, it will appear in position 9.
6. After all display positions have been filled, any further characters will be ignored.
7. The maximum number of characters that can be sent with the D command is 10. Any additional characters will be ignored.
8. Any + or - character will automatically be placed in position 8 if not the first character. Any other character placed into position 8 of the command string will be placed into position 9 of the display.

Programming Example—Enter the following statements into the HP-85 keyboard:

REMOTE 716 (END LINE)
OUTPUT 716; "D< sp> 195A <sp> X" (END LINE)

When the END LINE key is pressed the second time, the instrument model number will be displayed.

Display operation may be returned to normal with the following statement:

OUTPUT 716; "DX" (END LINE)

4.11 FRONT PANEL ERROR MESSAGES

The process of programming the Model 195A involves the proper use of syntax. Syntax is defined as the orderly or systematic arrangement of programming commands or languages. The Model 195A must receive valid commands with proper syntax or it will:

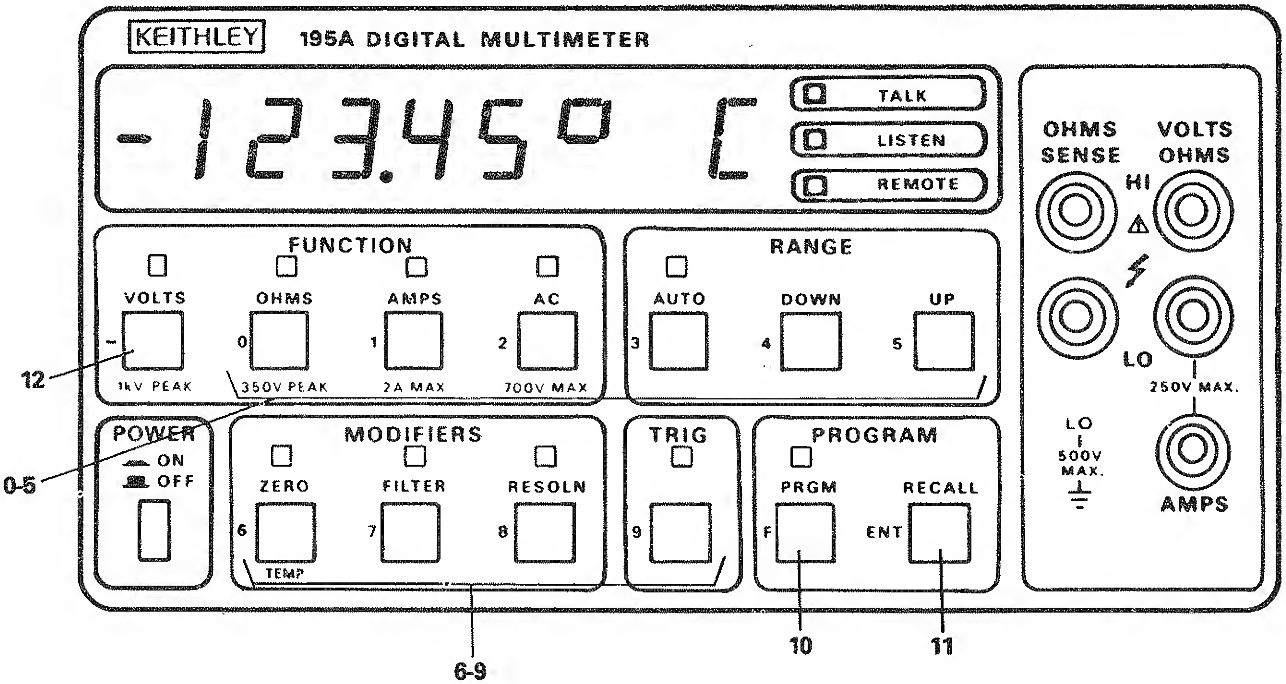


Figure 4-12. Hit Button Command Numbers

1. Ignore the entire command string in which the invalid command appears.
2. Set appropriate bits in the status byte.
3. Generate an SRQ if programmed to do so.
4. Display an appropriate front panel error message.

Device-dependent commands are sent as a string of several ASCII characters. Some examples of valid command strings include:

F0X	Single command string.
F0Q1B2X	Multiple command string.
F7X	Space is ignored.

Examples of invalid command strings are:

C0X	Invalid command; C is not a command.
F7X	Invalid command option; 7 is not an option of the F command.

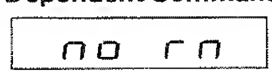
The numbers after the command are each interpreted as a decimal integer. For example:

T01.0X is interpreted as T1X.
TX means T0X.
T1.2 E-3X is T1X (the rest is ignored).

Figure 4-13 shows the front panel error messages employed by the Model 195A. The messages in Figure 4-13(a) results from an Illegal Device-Dependent Command (IDDC), while the message in Figure 4-13(b) results from an Illegal Device-Dependent Command Option (IDDCO). The no remote error message in Figure 4-13(c) results from attempting to program the instrument when it is not in the remote mode.

A. Illegal Device-Dependent Commands (IDDC)

B. Illegal Device-Dependent Command Option (IDDCO)



C. No Remote

Figure 4-13. IEEE Display Error Messages.

4.11.1 IDDC Error

An IDDC error results when the Model 195A receives an invalid command such as C1X. This command is invalid because no such letter exists in the instrument's programming language.

Programming Example—To demonstrate an IDDC error, enter the following statements into the HP-85 keyboard:

REMOTE 716 (END LINE)
OUTPUT 716; "C1X" (END LINE)

When END LINE is pressed the second time, the error message in Figure 4-13(a) is displayed for about one second.

4.11.2 IDDCO Error

An IDDCO error occurs when the numeric parameters associated with a legal command letter is invalid. For example, the command T9X has an invalid option because the instrument has no trigger mode associated with that number.

Programming Example—To deomstrate an IDDCO error, enter the following statements into the HP-85:

REMOTE 716 (END LINE)
OUTPTU 716; "T9X" (END LINE)

4.11.3 No Remote Error

A front panel no emote error message will be displayed if the Model 195A is not in the remote mode when it receives a command over the bus. If an attempt is made to program the instrument when it is not in the remote mode, the no remote message in Figure 4-13(c) will be displayed on the front panel for about one second.

Programming Example—To make sure the instrument is not in the remote mode, enter the following statement into the HP-85:

LOCAL 7 (END LINE)

Now enter the following programming statement into the keyboard'

OUTPUT 716; "G0X" (END LINE)

When this statement is executed, the no remote error message in Figure 4-13(c) is displayed on the front panel of the instrument for about one second.

4.12 READING RATES

The maximum reading rate depends on several factors, including selected S, buffer, and multiplex modes. Shown below are several conditions along with trigger to first byte out times for data transmission over the bus as well as buffer filling rates under certain operating conditions.

Modes	Measurement Conditions	Time	Comments
S0 T2 P0 W0 A0	ATN to DAV	17ms	Trigger to first byte out over bus.*
S1 T1 P0 W0 A0	ATN to DAV	30ms	Trigger to first byte out over bus.*
S0 T2 P0 W0 A1 Q1 B1 M4	GET to SRQ	100 readings in 1.25sec.	Buffer fits at maximum rate with multiplex off (A1).
S0 T2 P0 W0 A0 Q1 B1 M4	GET to SRQ	100 readings in 2.44sec.	Buffer fill rate with multiplex on (A0).

*Typical byte transfer rate is 0.5ms per byte. It takes about 10ms to transfer a reading depending on the controller and G modes.

S0 3.3ms Integration Period
S1 16.67ms Integration Period
T1 One-shot on talk trigger mode.
T2 Continuous on GET trigger mode.
P0 Filter disabled.
W0 No delay period.
A0 Multiplex on.
A1 Multiplex off.
Q1 Fill buffer and stop.
M4 Send SRQ when buffer is full.

SECTION 5
PERFORMANCE VERIFICATION

5.1 INTRODUCTION

This section contains information necessary to verify that Model 195A performance is within specified accuracy. Model 195A specifications may be found at the front of this manual. Ideally, performance verification should be performed when the instrument is first received to ensure that no damage or change in calibration has occurred during shipment. The verification procedure may also be performed whenever instrument accuracy is suspect or following calibration. If performance on any of the ranges or functions is substandard, calibration can be performed as described in Section 7.

NOTE

If the instrument does not meet specifications and it is still under warranty (less than 12 months since date of shipment), contact your Keithley representative or the factory to determine the action to be taken.

5.2 ENVIRONMENTAL CONDITIONS

All measurements should be made at an ambient temperature between 18° and 28°C (65° to 82°F) with a relative humidity less than 80%.

5.3 RECOMMENDED TEST EQUIPMENT

Recommended test equipment for Model 195A performance verification is listed in Table 5-1. Different equipment may be used as long as the accuracy specifications are at least four times better than equivalent Model 195A specifications. For less accurate test equipment additional allowances must be made in the readings obtained while performing the verification procedure. Some of the equipment listed in Table 5-1 does not have specifications at least four times better than those of the Model 195A because such equipment is not readily available. In such cases, the allowable range specified in the procedure includes the added uncertainty caused by the test equipment.

5.4 INITIAL CONDITIONS

Before performing the verification procedures, make sure the Model 195A meets the following conditions:

1. If the instrument has been subject to temperatures below 18°C (65°F) or above 28°C (82°F), allow sufficient time for the instrument to reach temperatures within this range. Generally, it takes one hour to stabilize an instrument that is 10°C (18°F) outside of this range.
2. Turn on the power to the Model 195A and allow it to warm-up for at least two hours before beginning the verification procedure.

Table 5-1. Recommended Test Equipment For Performance Verification

Description	Specifications	Manufacturer and Model
DC Voltage Calibrator	20mV, 200mV, 2V, 20V, 200V, 1100V ranges ±0.005% accuracy	Fluke 5101B
AC Voltage Calibrator	20mV, 200mV, 2V, 20V 200V, 1100V ranges ±0.05% accuracy.	Fluke 5101B
DC Current Calibrator	200μA, 2mA, 20mA, 200mA, 2A ranges ±0.025% accuracy.	Fluke 5101B
AC Current Calibrator	200μA, 2mA, 20mA 200mA, 2A ranges ±0.07% accuracy	Fluke 5101B
Power Amplifier		Fluke 5205A*
Decade Resistor	19Ω, 190Ω, 1.9kΩ, 19kΩ, 190kΩ, 1.9MΩ, 10MΩ ±0.01% accuracy	ESI RS725
Decade Resistance	±0.01% accuracy	Gen Rad Model 1433T

*For use with 5101B above 20kHz and 20V.

5.5 VERIFICATION PROCEDURE

The following paragraphs give the basic verification procedure for the following functions: DC volts, AC volts, resistance, DC current, AC current and temperature.

WARNING
The following procedures require that high voltages may be applied to the input terminals of the Model 195A. These procedures are intended only for qualified service personnel. Use normal precautions to avoid possible electric shock which could result in personal injury or death.

NOTES:

1. AC voltage and current, and DC current measurements require that the Model 1950 option be installed.
2. Place the instrument in the 5½ digit display mode before beginning the verification procedure.

5.5.1 DC Voltage Accuracy Check

The DC voltage verification procedure is done by applying an accurate DC calibration signal to the VOLTS OHMS terminals and then checking to see that the displayed value is within the required range.

CAUTION
Do not exceed 1000V between the VOLTS OHMS HI and LO terminals or damage to the instrument may occur.

Proceed as follows:

1. Select the DC volts function with the front panel VOLTS button. Use the AC button, if necessary, to cancel the AC mode. Initially, place the instrument on the 1000V range. Select 5½ digit resolution.
2. Connect the DC calibrator to the instrument as shown in Figure 5-1. The positive side of the calibrator output should be connected to the VOLTS OHMS HI terminal. Check to see that the front panel terminals are selected with the rear panel INPUTS switch.
3. Set the calibrator output to 0V and switch the Model 195A to the 20mV range. Enable the zero with the front panel ZERO button. Leave the zero enabled for all DC measurements. Check to see that the display shows 00.000 ± 4 counts.
4. Set the calibrator output to exactly 19.0000mV. Verify that the display shows a reading within the limits stated in Table 5-2.
5. Change the Model 195A to the 200mV range and change the calibrator output voltage to 190.000mV. Check to see that the displayed value is within the limits in Table 5-2.
6. Select the 2V range on the Model 195A and change the calibrator output to 1.90000V DC. The displayed reading should be within the limits specified in Table 5-2.
7. Switch the Model 195A to the 20V range. Set the calibrator output to 19.000V and verify that the displayed reading is within the limits set in Table 5-2.
8. Change the Model 195A to the 200V range and set the calibrator output to 190.00V. Check to see that the displayed value is within the limits in Table 5-2.
9. Change the Model 195A to the 1000V range and set the calibrator output to 990.00V. Verify that the displayed reading is within limits.
10. Reverse the output polarity of the calibrator and repeat the measurements with negative input voltages.
11. Place the INPUTS switch in the rear panel position and repeat the entire procedure using the rear panel VOLTS OHMS terminals.

Table 5-2. Limits for DC Voltage Verification

Model 195A DC Range	Calibrator Output	Allowable Range* (18°C to 28°C)
20mV	19.0000mV	18.9912 to 19.0088mV
200mV	190.000mV	189.946 to 190.054mV
2 V	1.90000 V	1.89954 to 1.90046V
20 V	19.0000 V	18.9937 to 19.0063V
200 V	190.000 V	189.944 to 190.056V
1000 V	990.00 V	989.69 to 990.31V

*Does not include calibrator tolerance.

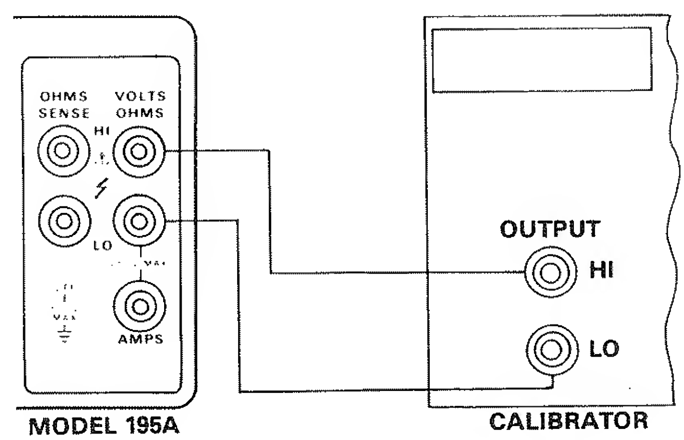


Figure 5-1. Connections for Voltage Verification

5.5.2 Resistance Accuracy Check

Resistance verification is performed by connecting known, precise resistance values to the VOLTS OHMS terminals and checking to see that the displayed reading is within the required limits. Measurements on the 20Ω, 200Ω and 2kΩ ranges will be done using the 4-terminal configuration to minimize errors due to the voltage drop across the test leads.

CAUTION

Do not exceed 250V RMS, 360V peak between the VOLTS OHMS terminals or the instrument might be damaged.

Proceed as follows:

1. Select the resistance function by pressing the front panel OHMS button. See that the rear panel INPUTS switch is in the front panel position. Select 5½ digit resolution.
2. Short the front panel VOLTS OHMS terminals together with a low-thermal shorting plug and enable the zero mode. Check to see that the display reads 0.0000±10 digits on the 20Ω range. Leave the zero enabled for all resistance measurements.
3. Connect a 19Ω calibration resistor to the instrument as shown in Figure 5-2. Note that the 4-terminal configuration is used for this measurement. Place the instrument on the 20Ω range and check to see that the displayed reading is within the limits in Table 5-3.
4. Connect a 190Ω calibration resistor to the instrument as shown in Figure 5-2. Switch the instrument to the 200Ω range and see that the displayed reading is within the limits set in Table 5-3.
5. Connect a 1.9kΩ calibration resistor to the instrument as shown in Figure 5-2. Switch the instrument to the 2kΩ range and check to see that the reading is within prescribed limits.
6. Connect a 19kΩ calibration resistor to the instrument as shown in Figure 5-3. Note that the 2-terminal configuration may be used for measurements on the 20kΩ and higher ranges. Place the instrument on the 20kΩ range and compare the reading with the limits in Table 5-3.
7. Continue with each of the calibration resistance values listed in Table 5-3. Be sure to place the Model 195A on the correct range for each measurement. The remaining readings may be done using the 2-terminal configuration.
8. Place the INPUTS switch in the rear panel position and repeat the entire procedure using the rear panel VOLTS OHMS terminals.

Table 5-3. Limits for Resistance Verification

Model 195A Range	Calibration Resistance Value	Allowable Range* (18°C to 28°C)
20 Ω	19 Ω	18.9909 to 19.0092 Ω
200 Ω	190 Ω	189.926 to 190.074 Ω
2 kΩ	1.9 kΩ	1.89934 to 1.90066kΩ
20 kΩ	19 kΩ	18.9926 to 19.0074kΩ
200 kΩ	190 kΩ	189.934 to 190.066kΩ
2MΩ	1.9MΩ	1.89879 to 1.90121MΩ
20MΩ	10MΩ	9.9840 to 10.0115MΩ

*Includes tolerance of decade resistor listed in Table 5-1.

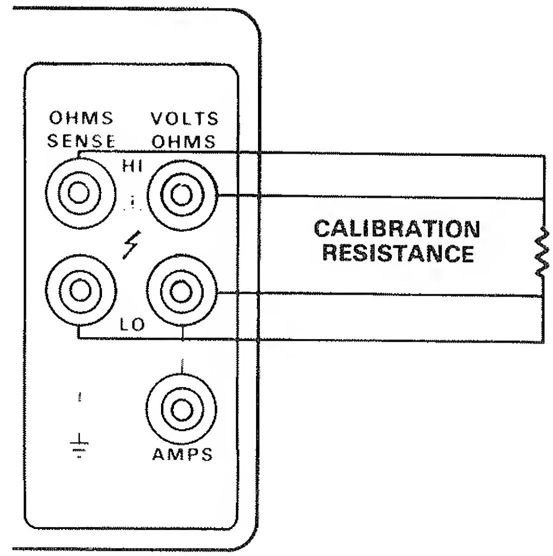


Figure 5-2. Connections for Verification of 20Ω, 200Ω, and 2kΩ Ranges

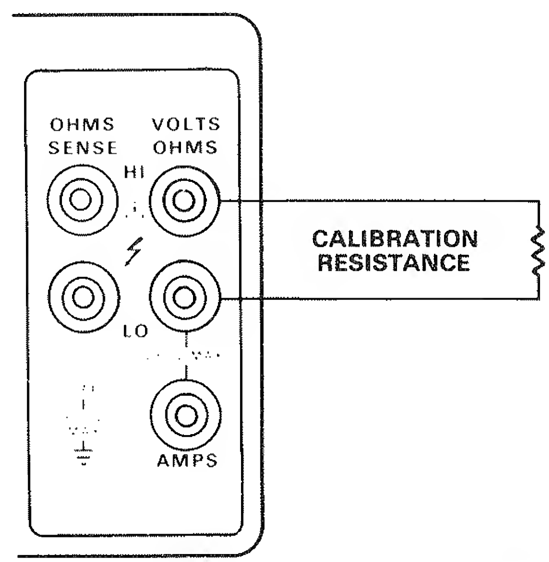


Figure 5-3. Connections for Verification of 20kΩ Through 20MΩ Ranges

5.5.3 AC Voltage Accuracy Check (with Model 1950 Option)

AC voltage accuracy is checked by connecting a calibrated AC voltage to the VOLTS OHMS terminals and then comparing the displayed reading with the allowable range of value.

NOTE

A "no OP" message will be displayed if the AC button is pressed without the Model 1950 option installed and programmed.

CAUTION

Do not exceed 700V RMS, 1000V peak between the VOLTS OHMS HI and LO terminals or instrument damage may occur.

Proceed as follows:

1. Select the AC volts function with the VOLTS and AC buttons. Initially, place the instrument on the 700V range. Do not use ZERO, but select 5½ digit resolution.
2. Connect the calibrator to the Model 195A as shown in Figure 5-1. Set the calibrator output to 190.000mV AC at a frequency of 50Hz. See that the INPUTS switch is in the front panel position.
3. Switch the Model 195A to the 200mV range and verify that the displayed reading is within the limits listed in Table 5-4. Repeat the 200mV range measurements at 20kHz and 50kHz.
4. Set the Model 195A to the 2V range. Select a calibrator output voltage if 1.90000V at a frequency of 50Hz and verify that the displayed reading is within the limits in Table 5-4. Repeat the 2V range measurements at 20kHz and 50kHz.
5. Select the 20V range on the Model 195A and change the calibrator output voltage to 19.0000V AC at 50Hz. Check to see that the displayed value is within the limits in Table 5-4. Repeat the 20V range measurements at 20kHz and 50kHz.
6. Switch the Model 195A to the 20V range and change the calibrator output to 190.000V at 50Hz. Verify that the displayed reading is within the limits in Table 5-4. Also, verify 200V range accuracy at 20kHz and 50kHz.
7. Switch the Model 195A to the 700V range and set the calibrator output to 690.00V at 50Hz. Check to see that the Model 195A reading is within the limits in Table 5-4. Repeat the 700V range measurement at 20kHz only.
8. Place the INPUTS switch in the rear panel position and repeat the entire procedure using the rear panel VOLTS OHMS terminals.

5.5.4 DC Current Accuracy Check (With Model 1950 Option)

DC current accuracy is checked by connecting a calibrated DC current source to the AMPS and VOLTS OHMS LO terminals and then verifying that the displayed value falls within a prescribed range.

NOTE

A "no OP" message will be displayed if the AMPS button is pressed without the Model 1950 option installed and programmed.

CAUTION

Do not exceed a 2A input value to the instrument or the amps fuse will blow.

Proceed as follows:

1. Select the DC current function with the AMPS button. If necessary, cancel the AC mode with the AC button. Initially, place the Model 195A on the 2A range. Select 5½ digit resolution.
2. Connect the DC current calibrator to the Model 195A as shown in Figure 5-2. The HI side of the calibrator output should be connected to the AMPS terminal and the LO side calibrator output should be connected to the VOLTS OHMS LO terminal. Make sure the rear panel INPUTS switch selects the front panel terminals. Set the calibrator output to 0.0000 and enable the zero mode.
3. Set the calibrator output to 19.0000μA and switch the Model 195A to the 20μA range. Verify that the reading falls within the limits specified in Table 5-5.
4. Switch the Model 195A to the 200μA range and set the calibrator output to 190.000μA. Check to see that the reading is within the limits listed in Table 5-5.

Table 5-4. Limits for AC Voltage Verification

Model 195A AC Range	Calibrator Outut Voltage	Allowable Range *(18°C to 28°C)		
		50Hz	20kHz	50kHz
200mV	190.000mV	189.180 to 190.82mV	188.420 to 191.500mV	185.900 to 194.100mV
2 V	1.90000 V	1.89230 to 1.90770V	1.88470 to 1.91530V	185.950 to 194.05V
20 V	19.0000 V	18.9230 to 19.0770V	18.8470 to 19.1530V	18.6900 to 19.3100V
200 V	190.000 V	189.230 to 190.770V	188.470 to 191.530V	186.900 to 193.10V
700 V	690.00 V	687.73 to 692.27V	683.17 to 696.83V	**

*Does not include calibrator tolerance.
**Do not perform 50kHz verification on 700V range.

5. Switch the Model 195A to the 2mA range and set the calibrator output to 1.90000mA. See that the reading is within the limits specified in Table 5-5.
6. Change the Model 195A to the 20mA range and set the calibrator output to 19.0000mA. Verify that the displayed value is within limits.
7. Select the 200mA range on the Model 195A and change the calibrator output to 190.000mA. See that the reading is within the limits stated in Table 5-5.
8. Select the 2A range on the Model 195A and change the calibrator output to 1.90000A. See that the reading is within the limits listed in Table 5-5.
9. Reverse the calibrator output polarity and repeat the procedure in steps 3 through 8.
10. Repeat the procedure with the rear panel terminals.

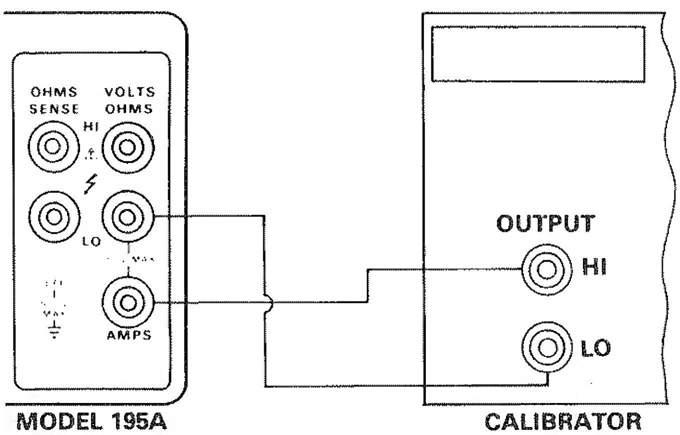


Figure 5-4. Verification Connections for Current

Table 5-5. Limits for DC Current Verification

Model 195A Range	Calibrator Output	Allowable Range* (18°C to 28°C)
20 μA	19.0000 μA	18.9694 to 19.0306μA
200 μA	190.000 μA	189.819 to 190.181μA
2mA	1.90000mA	1.89819 to 1.90181mA
20mA	19.0000mA	18.9819 to 19.0181mA
200mA	190.000mA	189.819 to 190.181mA
2 A	1.9000 A	1.89819 to 1.90181 A

*Does not include calibrator tolerance.

5.5.5 AC Current Accuracy Check (with Model 1950 Option)

AC current accuracy is checked by connecting a calibrated AC current source to the AMPS and VOLTS OHMS LO terminals and then verifying that the displayed value falls within a specified range.

NOTE
Pressing AMPS or AC without the Model 1950 option installed and programmed will result in a "no OP" message.

CAUTION
Do not exceed a 2A input value or the amps fuse will blow.

Proceed as follows:

1. Select the AC current function with the AMPS and AC buttons. Initially, place the instrument on the 2A range; select 5½ digit resolution.
2. Connect the AC calibrator to the instrument as shown in Figure 5-4. Set the calibrator frequency to 1kHz and see that the Model 195A INPUTS switch is in the front panel position. Do not use ZERO in the AC mode.
3. Set the calibrator output to 190.000μA and switch the Model 195A to the 200μA range. Verify the reading is within the limits listed in Table 5-6.
4. Change the Model 195A to the 2mA range and switch the calibrator output to 1.90000mA. See that the displayed value falls within the prescribed limits listed in Table 5-6.
5. Select the 20mA range on the Model 195A and increase the calibrator output to 19.0000mA. Compare the displayed reading with the limits set in Table 5-6.
6. Switch to the 200mA range and select an output current of 190.000mA. Verify that the reading is within limits.
7. Place the Model 195A on the 2A range and change the calibrator output to 1.90000A. See that the reading is within limits.
8. Repeat the procedure with the rear panel terminals.

Table 5-6. Limits for AC Current Verification

Model 195A AC Range	Calibrator Output	Allowable Range* (18°C to 28°C)
200μA	190.000μA	188.560 to 191.44μA
2mA	1.90000mA	1.88560 to 1.9144mA
20mA	19.0000mA	18.8560 to 19.144mA
200mA	190.000mA	188.560 to 191.44mA
2 A	1.90000 A	1.88560 to 1.9144 A

*Does not include calibrator tolerance.

5.5.6 Temperature Accuracy Check

Model 195A temperature verification is based on substituting precise, known resistance values for the temperature probe and seeing that the displayed reading falls within the required range.

NOTE
The following procedure assumes the instrument is calibrated for the DIN 43 760 standard (alpha = 0.00385). Other standards will require different resistor values. See Section 7 for information on calibration.

WARNING
To avoid possible shock hazards, disconnect all other test leads from the unit before connecting the decade box.

1. Connect the precision decade resistance box to the Model 195A as shown in Figure 5-5. Four wire connections must be used as shown on the diagram. Make sure the INPUTS switch is in the front panel position and that the instrument is programmed for 4-wire operation.
2. Enter the °C temperature mode by pressing the PRGM and 6 buttons in sequence. If the display shows unit is in the °F mode, press PRGM and 6 in sequence again. Make sure the display is in the 5½ digit resolution mode; also see that ZERO is disabled.
3. Refer to Table 5-7, which summarizes the verification resistance values. To check Model 195A accuracy at each of the points, set the decade box to the indicated resistance value and see that the displayed Model 195A reading falls within the required range.

Table 5-7. Limits for Temperature Verification

Nominal Temperature	Resistance Value	Allowable Reading (18° to 28°C)
-200°C	18.49Ω	-200.12 to -199.80°C
-100°C	60.25Ω	-100.13 to -99.87°C
0°c	100.00Ω	-0.10 to +0.10°C
+100°C	138.50Ω	+99.87 to +100.13°C
+200°C	175.84Ω	+199.84 to +200.16°C
+400°C	247.04Ω	+399.48 to +400.56°C
+600°C	313.59Ω	+599.42 to +600.58°C

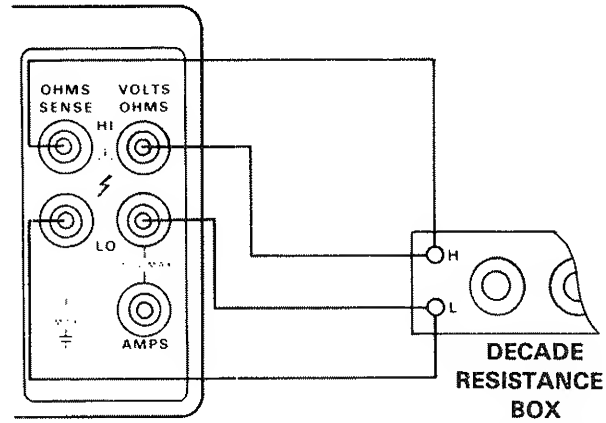


Figure 5-5. Connections for Temperature Verification

SECTION 6
THEORY OF OPERATION

6.1 INTRODUCTION

This section contains an overall functional description of the Model 195A as well as detailed circuit analysis of the various sections of the instrument. Information pertaining to the standard IEEE interface and the Model 1950 AC/current option is also included.

Information is arranged to provide a description of individual functional circuit blocks. As an aid to understanding, the descriptions are keyed to accompanying block diagrams and simplified schematics. Detailed schematics and component layout drawings are located at the end of this instruction manual.

6.2 OVERALL FUNCTIONAL DESCRIPTION

The Model 195A is a 5½ digit, ±200,000 counts temperature reading DMM with six DC voltage ranges and seven resistance ranges in standard configuration. With the Model 1950 option installed, the Model 195 capabilities are expanded to include AC voltage and AC and DC current measurements.

The Model 195A uses a hybird A/D (Analog-to-Digital) converter which uses both charge balance and single-slope conversion techniques. The A/D conversion process is controlled by an 8-bit microcomputer which supervises all operating aspects of the instrument. These two circuits combine to give the Model 195A high accuracy, high conversion speeds, and fast settling times.

A simplified block diagram of the Model 195A is shown in Figure 6-1. The instrument is essentially divided into two sections, analog and digital. These two sections are electrically isolated by using opto isolators for data and control communications, and an isolated power transformer with separate analog and digital supplies. The method of isolation allows the LO input terminals to be connected to a potential up to ±500V from chassis ground. At the same time, digital common, which includes IEEE common, can be operated at a potential up to 30V with respect to chassis ground.

The heart of Model 195A operation centers around the A/D converter. Since the input signal is in analog form, and the microcomputer "speaks" only digital, the A/D converter must provide the necessary conversion process. However, the signal must first be properly conditioned into a form usable by the A/D converter.

The input signal is applied through the input switching circuit that selects front or rear panel terminals. If the Model 1950 option is installed, applied voltage and current signals are controlled or modified into the proper form and applied to the multiplexer. The multiplexer applies the various input signals such as zero and -2V reference to the buffer amplifier in a sequential manner. Timing is ultimately determined by the microprocessor.

The input amplifier buffers the signal and gives gain when necessary. The A/D converter, working under the control of the MPU, provides a serial output which is coupled through the opto isolator to the microcomputer. The microcomputer, working under software control, then converts the data into a form suitable for the display or IEEE bus. Also, the microcomputer provides a serial control signal which is coupled through an opto isolator to ultimately control the A/D converter and the multiplexer.

6.3 ANALOG CIRCUITRY

The following paragraphs contain a description of the input multiplexer, buffer amplifier, -2V reference and A/D converter circuits. These circuits may be found on the 195-106 schematics located at the end of this manual. The multiplexer, buffer and -2V reference circuits are located on the input schematic, while the A/D converter can be found on the A/D converter schematic. Each paragraph in this section is accompanied with a simplified schematic of the subject material for easier understanding.

6.3.1 Input Switching and Multiplexer

Input switching is accomplished by the INPUTS switch, S103. K101 and K102 provide volts/ohms switching and input attenuator control.

The multiplexer, which is shown in Figure 6-2, is made up of nine JFETs which are ultimately controlled by the microprocessor through a BCD to binary decoder (U131) and nine FET drivers (U130, U136, U140 and U142). These drivers are necessary to convert digital voltage levels into signals usable by the FETs. For example, to turn each FET off, a potential of approximately -14V is applied to its gain.

Ordinarily, FET switching creates transients which could be seen in the final measurement. These effects are minimized in the Model 195A through the use of software-generated delays and by shorting the multiplexer bus to signal common for a portion of each input cycle through zero FET, Q114.

The multiplexer connects one of the nine signals to the buffer amplifier in a sequential manner, but not all signals are used for a given input sequence. For example; for a 20VDC measurement, only Q103, Q113 and Q114 are switched on at the proper times.

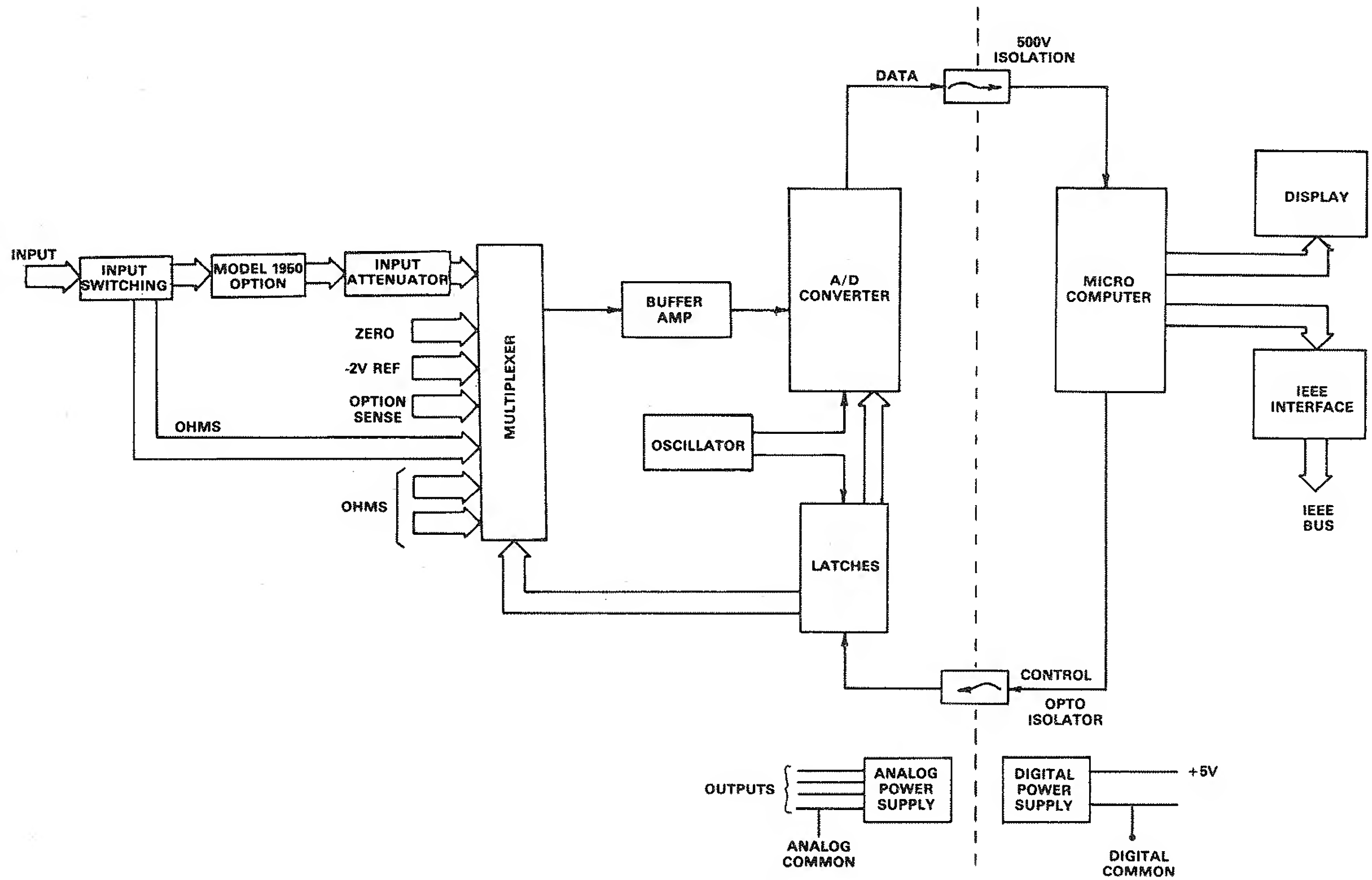


Figure 6-1. Basic Block Diagram

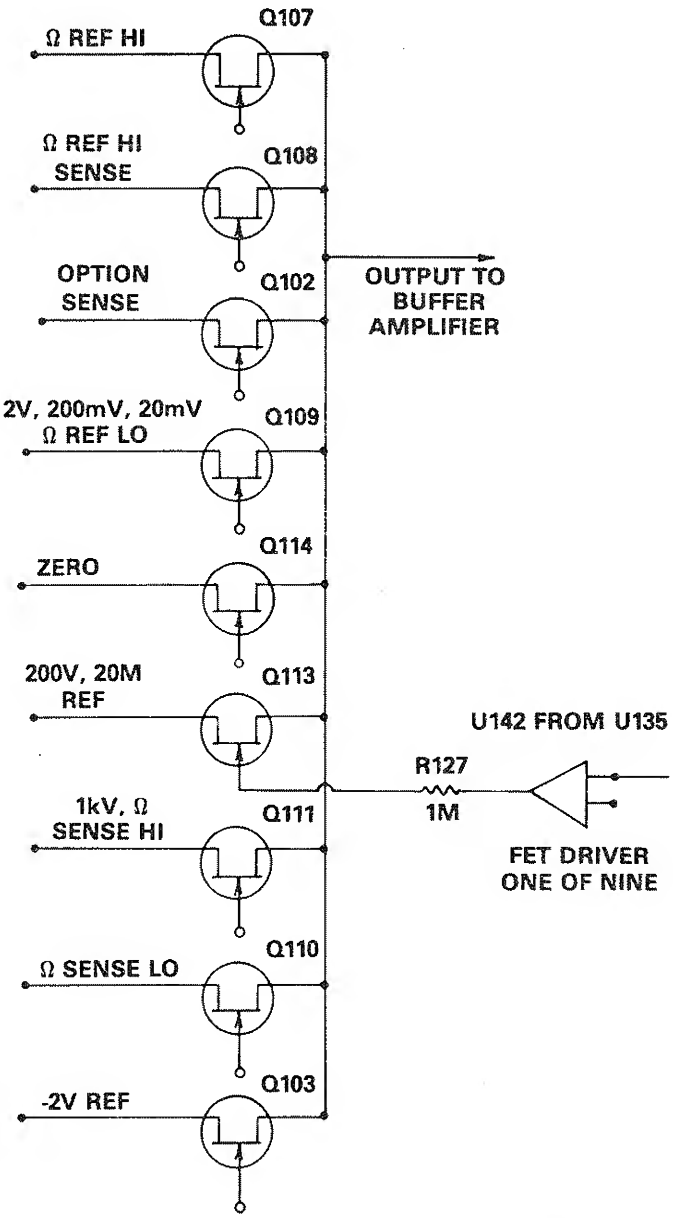


Figure 6-2. Simplified Schematic of the Multiplexer

6.3.2 Input Buffer Amplifier

The input buffer amplifier, which is shown in Figure 6-3, provides the necessary isolation between the multiplexer and the A/D converter. This amplifier is a noninverting, low noise, high impedance circuit with switchable X1, X2, X10 or X100 gain capabilities. The gain factor depends on the required sensitivity of the instrument on the given range.

The buffer amplifier uses two operational amplifiers which combine to give the necessary high input impedance and low noise characteristics along with the required open loop gain. The first op amp, U131, was chosen for its low-noise characteristics, while the second op amp, U137 provides the additional open loop gain.

Buffer amplifier gain control is achieved by switching various feedback resistors elements in and out of the circuit. The feedback resistors include R123 and the three elements of R136. JFETs Q117 through Q119 are switched on or off as required to provide the required X1, X2, X10 or X100 gain factors. These switching FETs are driven by three sections of U130 which provide the necessary voltage conversion factor. Switching is ultimately controlled by the microprocessor, which feeds control signals to the serial-parallel conversion section made up of U124, U129 and U140. Q118 and Q119 are turned on simultaneously for X2 gain.

6.3.3 -2V Reference Source

Model 195A voltage and current measurements are base on comparing the signal to be measured with an internal -2V reference voltage. During each measuring cycle, the microprocessor briefly samples the -2V reference and uses it as a base value as an aid in computing the final displayed reading.

The -2V reference source, which is shown in Figure 6-4, is made up of a highly stable zener diode, an op amp, and a resistive voltage divider. VR105 is a nominal 6.35V zener diode which has high inherent stability. U143 acts to keep the zener current constants, minimizing variations in zener voltage. The two elements of R128 form a resistance voltage divider to divide down the 6.35V zener voltage to its final 2V value. Since both elements of the divider are contained within one package, drift due to thermal effects are minimized.

6.3.4 A/D Converter

The Model 195A uses a hybrid A/D converter that used both charge balance (CB) and single-slope (SS) integration techniques. This integration method gives the instrument high accuracy, high speed, and fast settling times.

A simplified schematic of the A/D converter used in the Model 195A is shown in Figure 6-5. Figure 6-6 shows typical integration waveforms. Converter operation centers around the transconductance amplifier (U138 and Q116), the integrator (U134), and the single-slope comparator (U133). A/D timing is provided by a 614.4kHz clock, which controls the CB phase through U127A and U127B. Single-slope enable and integrator input disable are controlled by the microprocessor.

The signal from the buffer amplifier is applied to the input of the transconductance amplifier. This amplifier performs two functions: first, it converts the input voltage into a current usable by the integrator. Second, it converts the bipolar input signal into a unipolar output signal.

The A/D converter operates first in a CB phase and then in the SS phase. The integration period is normally 16.6ms at 60Hz, and 20ms at 50Hz. These periods were chosen as the best compromise between good line frequency rejection and fast conversion speed.

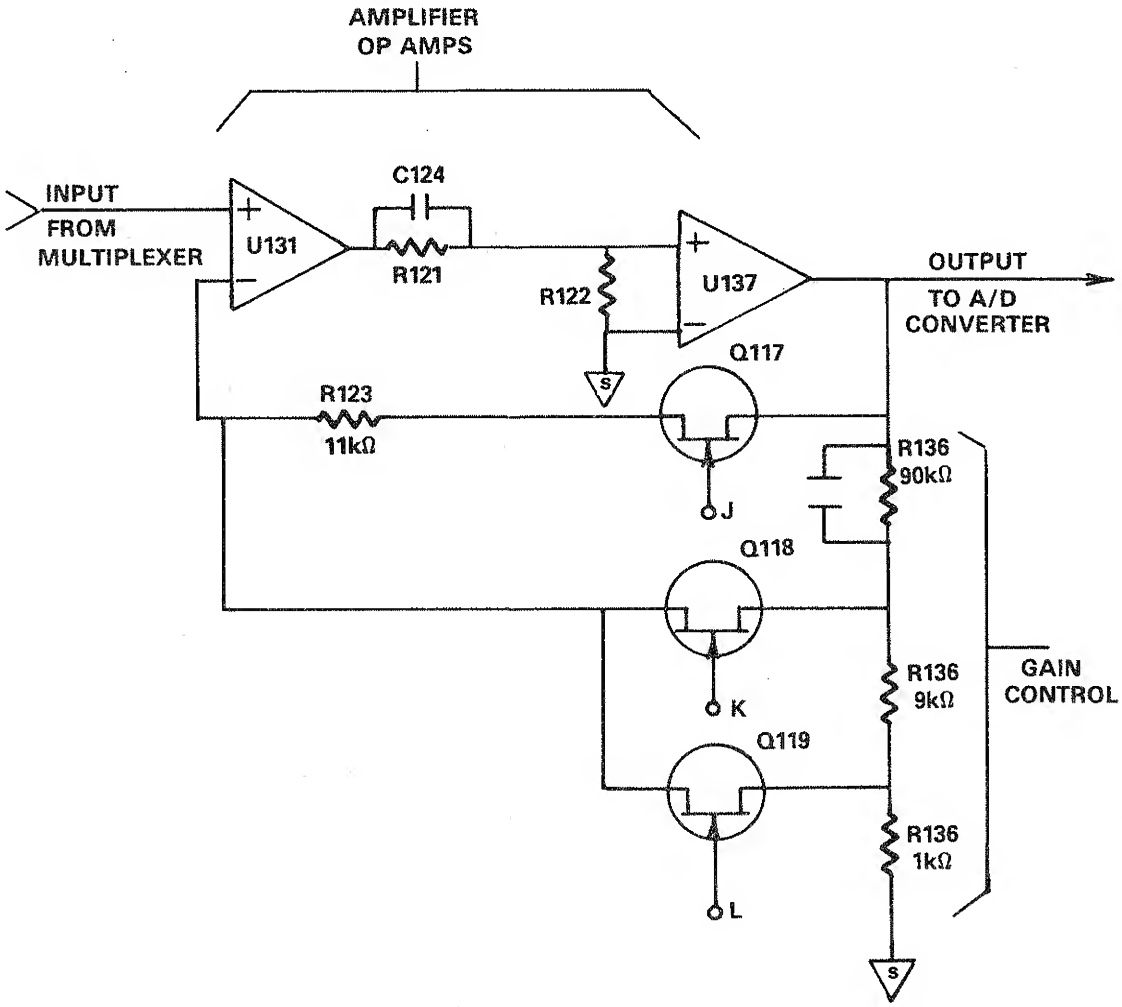


Figure 6-3. Simplified Schematic of the Input Buffer Amplifier

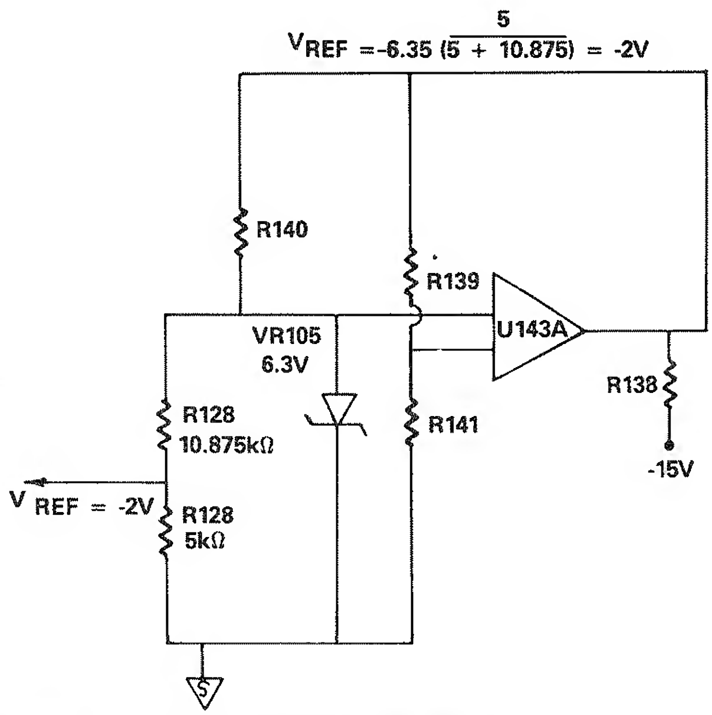


Figure 6-4. Simplified Schematic of the -2V Reference Source

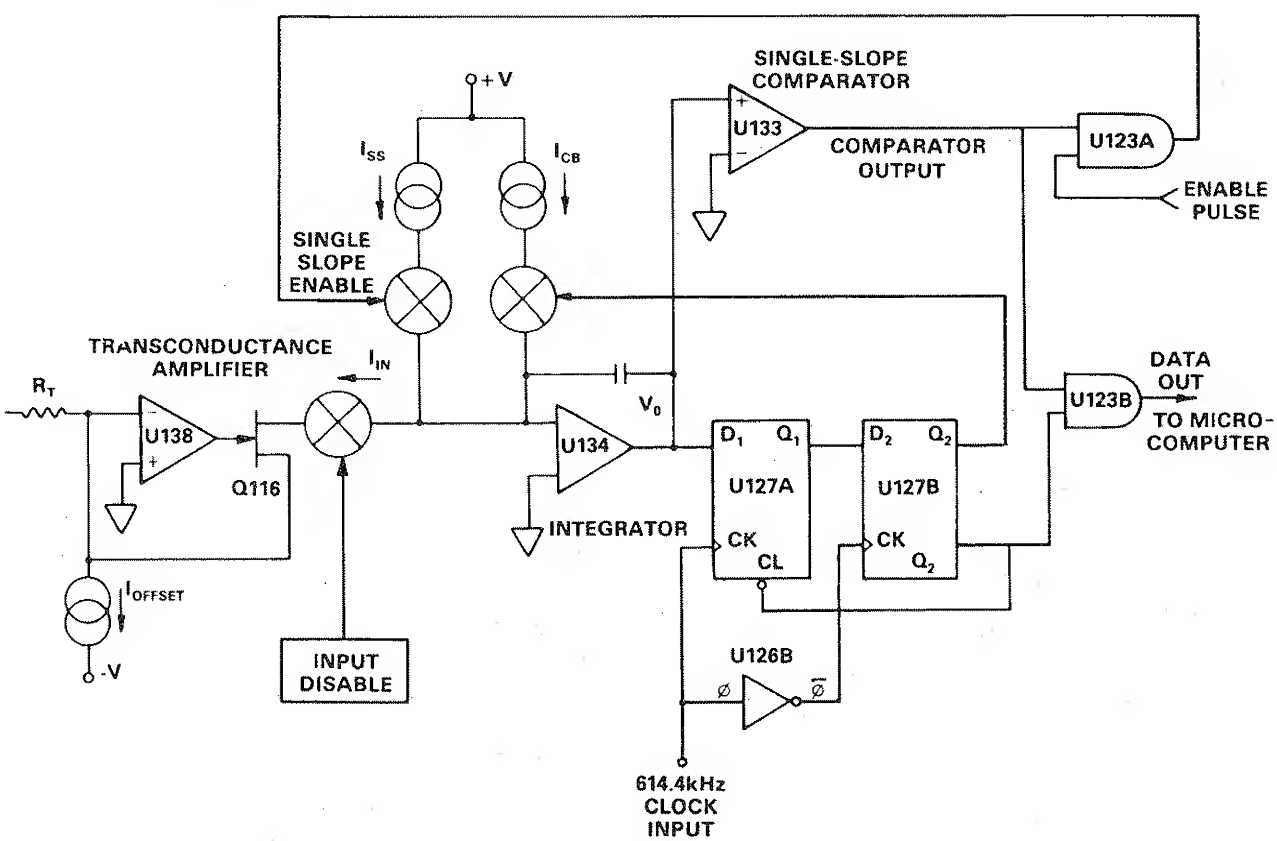


Figure 6-5. Simplified A/D Converter Schematic

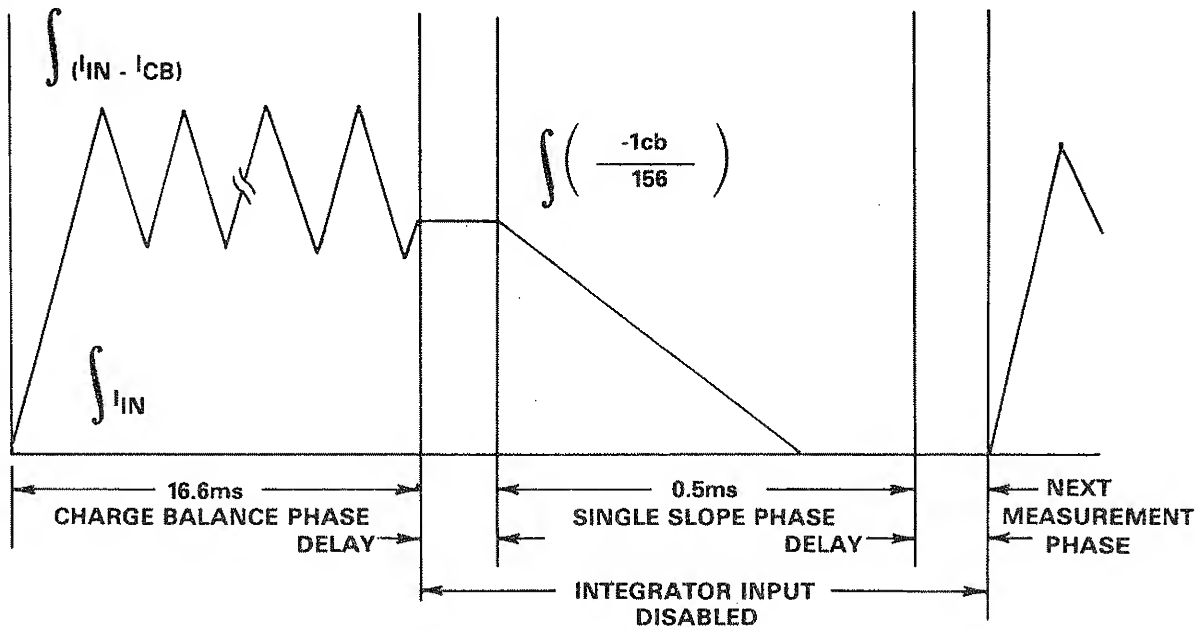


Figure 6-6. A/D Converter Integrator Output Waveform

The CB phase begins when the input disable line is set low. This occurs at the end of a software-generated delay period that allows the signal to settle after the appropriate multiplexer FET is turned on. The actual delay period depends on the selected range and function as summarized in Table 6-1.

Once the input disable line goes low, the input signal I_{IN} is applied to the integrator input, and the integrator output voltage, V_O ramps in the positive direction. Once this voltage reaches the turn-on threshold of the D input of U127A, Q1 of U127A goes high with the next positive going clock pulse. With the next subsequent negative going pulse, Q2 goes high, connecting I_{CB} to the integrator input. Since I_{CB} is much greater than I_{IN}, the integrator output voltage immediately ramps in the negative direction. With the next clock pulse, Q2 goes low, turning off the CB current. At the same time, Q2 goes high, resetting Q1.

At this point, I_{CB} has been turned on for one clock cycle (1.62μs) and then turned off. The earliest that I_{CB} can be turned on again is one clock cycle later. The two D-type flip-flops essentially divide the 614.4kHz clock signal in half to 307.2kHz. Each time $\overline{Q2}$ goes high, a counter in the microcomputer is incremented. With a 16.6ms integration period, the maximum number of counts is 16.6ms × 307.2kHz = 5,108 counts.

At the end of the charge balance phase, the output of the integrator is resting at some positive voltage. Since the integrator output is connected to the noninverting input of the single-slope comparator, the comparator output is also positive and will not go negative until the integrator output goes negative. The SS comparator output is ANDed with a pulse from the microprocessor to form the single-slope enable pulse. When the single-slope enable pulse is high, I_{SS} is connected to the integrator input for the duration of the SS phase, which has a period of approximately 500μs. The microprocessor determines the period that the single-slope enable pulse remains active; when sufficient counts of its clock have occurred, the MPU cancels the single-slope enable pulse and I_{SS} is disconnected from the integrator input.

Table 6-1. Integration Delay Periods

Function	Range	Delay Period (ms)*
DCV	All	6.5
ACV	All	6.5
Ohms	20Ω-2MΩ 20MΩ	6.5 50
AC & DC Current	All	6.5

*Includes 1.5ms fixed hardware delay.

6.4 DIGITAL CIRCUITRY

Model 195A operation is supervised by the internal microcomputer. Through the MPU, the A/D conversion process, front panel switching, display, and IEEE operation are all performed under software control. This section briefly

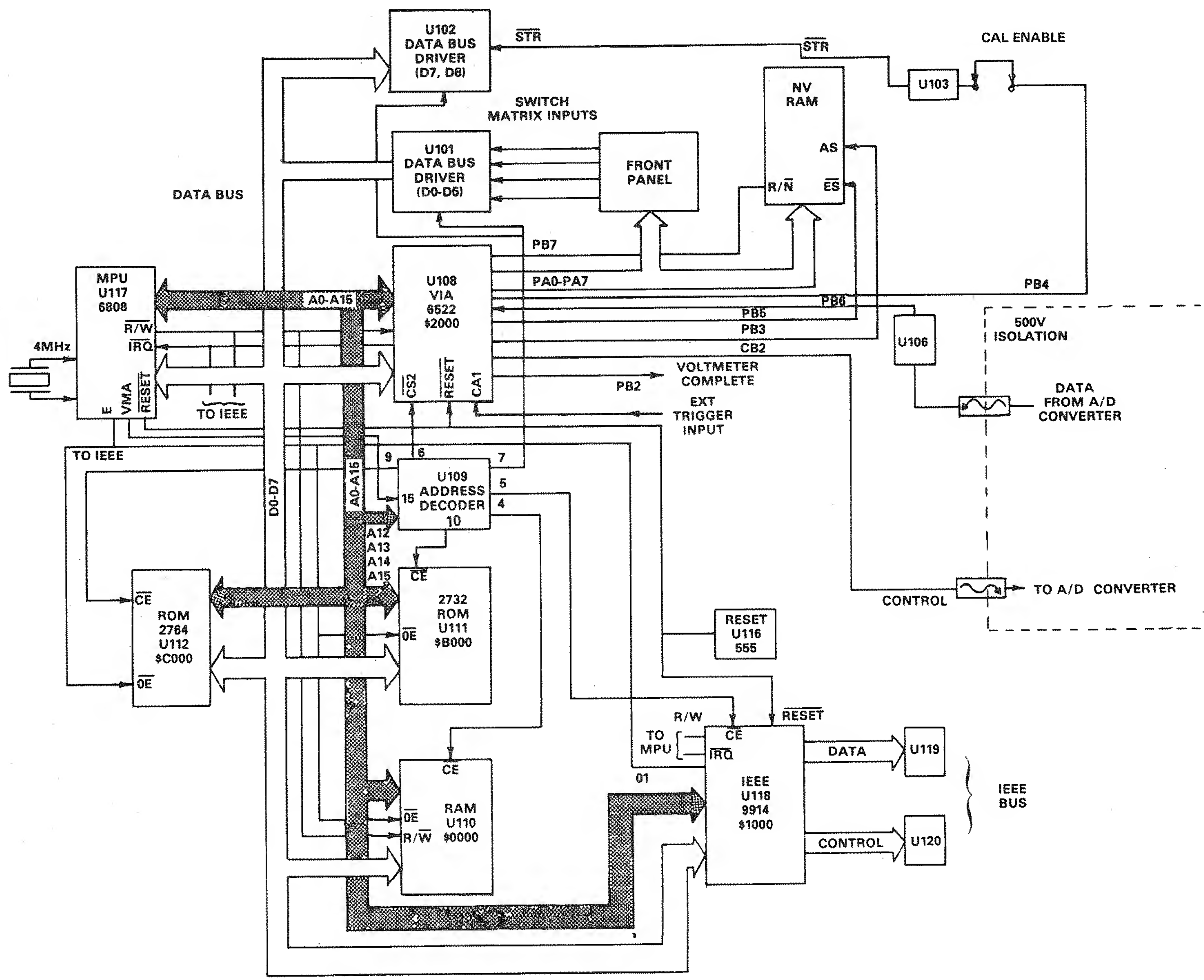


Figure 6-7. Simplified Microcomputer Block Diagram

describes the operation of the various sections of the microcomputer and associated digital circuitry. A simplified block diagram is included for user reference; for more complete circuit details refer to digital schematic number 195-106 at the end of this manual.

6.4.1 Microcomputer Block Diagram

A block diagram of the Model 195A microcomputer is shown in Figure 6-7. Circuit operation centers around the microprocessor unit (MPU), U117. The 6808 is an 8-bit microprocessor capable of directly addressing up to 64K bytes of memory. Clock generation circuits are integral within the chip; the only external component required is the 4MHz crystal. The clock frequency is internally divided to provide a bus operating frequency of 1MHz.

Software for the MPU is contained in two PROMs (Programmable Read-Only Memory). U112 is a 2764 PROM containing 8K bytes of software, while U111 is a 2732 PROM with 4K bytes. Temporary storage is provided by U110, a RAM (Random Access Memory) which can store up to 2048 bytes of information.

Much of the interfacing between the MPU and other circuitry is performed by U108, a 6522 VIA (Versatile Interface Adapter). This IC contains two 8-bit I/O ports and associated handshake lines. In the Model 195A, the VIA performs interfacing between the display,non-volatile RAM, trigger input and output, and serial transmission between the digital section and the A/D converter.

The non-volatile RAM is actually an EAROM (Electrically Alterable Read-Only Memory) that is used to stored calibration constants, line frequency values, and the IEEE primary address. Control of the NVRAM is performed by the VIA and associated circuitry.

Interfacing between the MPU and the IEEE bus is performed by a dedicated IEEE-488 bus interface IC, U118. This IC performs many bus functions automatically to minimize MPU overhead. Buffering between the 9914 IC and the IEEE bus lines is done with bus drivers U119 and U120.

6.4.2 Memory Mapping

The 6808 microprocessor is capable of directly addressing a total of 64K (65,536) bytes of memory. In hexadecimal notation, these bytes are assigned contiguous addresses between $0000 and $FFFF (the dollar sign preceding the address indicates a hexadecimal, or base 16 value). Although the MPU has this large addressing capability, only a portion of the possible memory space is actually needed.

The Model 195A uses a total of 12K PROM memory and 2K of RAM. Since the 6808 MPU uses a memory-mapped I/O scheme, additional memory locations must be allocated for the various I/O functions. Table 6-2 lists the memory locations for the various memory elements.

The RAM, IEEE chip, VIA, and buffer are each allocated a 4K slot of memory. However, the actual memory slots for each device is much less than that. This is the result of the partial decoding scheme used in the instrument. Similarly, 16K blocks are reserved for the two PROMS, even though they take up only 8K and 4K respectively.

6.4.3 Address Decoding

The MPU has a total of 16 address lines which are used to locate a specific memory slot. Since no memory or interface element can fully decode address locations, additional address decoding must be used.

U109 contains two two-line-to-four-line decoders. One section is connected to address lines A15 and A14. This section effectively decodes the memory locations into 16K blocks. The second section of the decoder is connected to address lines A13 and A12. This decoder section further divides the lowest 16K section ($0000-3FFF) into 4K sections to decode the RAM, IEEE chip, VIA, and buffer.

Since partial decoding is used, each portion of memory will respond to many different addresses. For example, PROM U111 is allocated the memory space from $B000 to $BFFF, but it will respond to addresses in the $8000-AFFF range.

Table 6-2. Model 195A Memory Mapping

Selected Device	Allocated Memory	Actual Memory Locations	Address Lines			
			A15	A14	A13	A12
RAM (U110)	$0000-$0FFF	$0000-$08FF	0	0	0	0
IEEE (U118)	$1000-$1FFF	$1000-$1007	0	0	0	1
VIA (U108)	$2000-2FFF	$2000-$200F	0	0	1	0
Buffers (U101 & U102)	$3000-$3FFF	$3000	0	0	1	1
PROM (U111)	$8000-$BFFF	$B000-$BFFF	1	0	X	X
PROM (U112)	$C000-FFFF	$C000-$DFFF	1	1	X	X

X = Don't Care

6.4.4 Microcomputer Reset

The 6808 MPU, 6522 VIA, and 9914 GPIA must be properly initialized upon power-up. each of these ICs has a $\overline{\text{RESET}}$ terminal which must be held low for a brief period of time when power is first applied to the instrument. The function is performed by U144, which is a micro-power voltage detector. The threshold of this IC is set by the value of R162 and R164. When power is firs applied, C135 holds pin 3 of U144 low for about 20ms, with the result that the $\overline{\text{RESET}}$ line is also held low during this period. When the $\overline{\text{RESET}}$ goes high, the registers in the 9914 and 6522 ICs are cleared, and the MPU program counter is loaded with the reset vector to begin initialization.

During normal operation, U144 monitors the state of the V_{CC} (+5V) line. If the voltage drops below 4.5V, U144 forces $\overline{\text{RESET}}$ low to make sure that the data contained in the NVRAM is not inadvertently changed during the power down cycle.

6.4.5 6522 VIA

U108, a 6522 VIA integrated circuit, performs many of the interfacing tasks between the MPU and the rest of the instrument. This IC is a highly versatile I/O chip with two bidirectional I/O ports, a serial shift register, and two 16-bit timers. The IC has a total of 16 registers which can be accessed by the MPU.

Port A (PA0-PA7) is used to control the front panel display and the non-volatile RAM. Some lines on Port B also control the NVRAM and provide the serial link between the MPU and the A/D converter, including control and data. Additional control functions are provided by the remainder of Port B I/O lines.

6.4.6 IEEE Interface

The Model 195A has a built in IEEE-488 interface that allows the instrument to be controlled through the system controller. Commands may be given over the bus and data may be requested from the instrument as well.

The IEEE interface is made up of U118, a 9914 GPIA (General Purpose Interface Adapter), and U119 and U120, which are interface bus drivers. On the MPU side of the GPIA, data transmission is handled much like any other bus transaction. The MPU accesses the GPIA through the usual D0 through D7 data lines. Address decoding for the 14 internal registers (7 read and 7 write) is provided by the $\overline{\text{CE}}$, $\overline{\text{WE}}$, and RS0, RS1, RS2 terminals.

The output of the 9914 IC is in standard IEEE format; the eight data lines (D101 through D108) the three handshake lines (DAV, NDAC, NRFD), and the five management lines (ATN REN, IFC, SRQ, EOI), are all active low with approximately zero volts representing a logic one. The two IEEE bus drivers, U119 and U120 are necessary to bring the drive capability of the interface up to the normal IEEE maximum of 15 devices.

The GPIA simplifies MPU interfacing to the IEEE bus because many control sequences take place automatically. For example, when a write is done to the data output register, the handshake sequence is automatically performed at the proper time. Without the GPIA chip, complicated MPU routines would be required to accomplish control sequences that are performed automatically.

6.4.7 Display Board

The display board, which can be found on schematic number 195-116, contains the numeric display LEDs, display indicator LEDs, and the function and mode switches.

Display information is fed from Port A of the VIA (PA0-PA7). Information is updated at a 1.2kHz rate which means that each segment is turned on for approximately 833μs. Each update period begins by placing display information on the PA0-PA7 lines and applying a clock pulse to U203 through CA2. This causes an enable pulse to be shifted to the right one digit with each clock pulse, causing the display digits to be enabledin sequence. With every eighth clock pulse, an enable pulse is applied to the shift register data input via PB5.

Q203 through Q207 are the display segment drivers; these transistors are necessary because the VIA output port has insufficient drive capability for the LEDs. These drivers in conjunction with the Q_H output of U203 also control DS212-DS217, which are the front panel annunciator lights.

Front panel switches S204 through S213 form a 4 × 4 switch matrix (only 13 positions are used, however). The switches are driven by the Q_A through Q_D outputs of the shift register and switch data is transmitted to the MPU through the switch buffer (U101) in the digital section.

6.4.8 Serial-Parallel Conversion

For the following discussion, refer to the A/D converter schematic number 195-106. The analog and digital sections of the instrument are electrically isolated. To simplify interfacing, serial transmission of data and control information is achieved by feeding the data through two opto isolators, U104 and U105. On the MPU end, serial-parallel conversion is performed by MPU software. On the A/D end, conversion information is performed by 8-bit shift registers and associated circuitry.

Serial control information is fed from the microcomputer through optoisolator U104. A pulse width modulation scheme is used, with a 2μs pulse representing a logic 0, while a 4μs pulse corresponds to a logic 1. The control information actually controls two synchronous counters, U124A and U124B. These control pulses are fed directly to the reset terminal of U124B, while the pulses are first inverted by U121 before being applied to the reset terminal. The control pulses, in inverted form, also clock several shift registers.

The conversion process is performed in two phases. During the first phase, a 24-bit data word is shifted into U129, U140, and, if the Model 1950 option is present, into U504 on that option board. Each of these devices is an 8-bit shift register/latch. During the second phase of conversion, the data is latched into the outputs of the three shift register/latches.

The shift-in phase is controlled by U124A, a 1.2288MHz clock pulse, and the inverted control pulses. The Q2 output of U124A is applied to the D input of U129. The normal count period for this counter is about 3.5μs. However, since the reset terminal of this counter is connected to the incoming control pulses, their duration determines whether or not sufficient time will elapse for the Q2 output of U124A to go high. For example, with a logic zero control pulse (2μs duration), the counter will reset before sufficient counts occur, so a logic 0 is clocked into U129. Conversely, a 4μs control pulse (logic 1) allows sufficient time to elapse for the Q2 output of U124A to go high, so a logic 1 is clocked into U129 under these conditions.

This process continues, with one bit clocked into U129 with every control pulse cycle. Once all eight positions in U129 are filled, data then streams out of the QS output of U129 to the D input of U140. After another eight control pulse cycles, data is fedout the QS output of U140. If the Model 1950 option is installed, the pulses are clocked into U504 on that option board.

Once all 24 bits have ben shifted in, the shift registers must be strobed before data is latched into their outputs. This action is performed by U124B, the 614.4kHz clock, and the incoming control pulses. The normal count period of the Q3 output of U124B would be about 13μs. However, since the control pulse information is applied to the reset terminal of this counter, it is continuously being reset during the shift-in phase, so no strobe action takes place. However, after the 24-bits are shifted in, the control line is held low for about 20μs. This allows sufficient time for the Q3 output to go high, strobing the shift registers, latching data into the outputs.

Some of the latch outputs are applied directly through drivers to provide the necessary switching functions. For example, the Q1 through Q3 outputs of U140 control buffer amplifier gain switching FETs Q117, Q118, and Q119 on the input circuitry. In other cases, additional decoding is used. For example, the Q5 through Q8 outputs of U129 are further decoded by U135, a BCD to binary decoder. The outputs of the decoder are used to control the input multiplexer by switching associated FETs on and off at the appropriate times.

6.5 POWER SUPPLY

For the following discussion, refer to the power supply schematic number 195-106 at the end of this manual. The power supply is made up of a line fuse, power on-off switch, line voltage selection switch, power transformer, three bridge rectifiers, four regulators, and various filter capacitors.

Fuse F101 is the LINE FUSE which is accessible on the rear panel. S101 is the power on/off switch and S102 selects 115V or 230V operation by placing the transformer primary windings in parallel or series.

T101, the power transformer, is specially shielded and insulated to provide the necessary 500V isolation between the analog and digital supplies. This special shielding also helps to minimize the coupling of the power line transients through the transformer into one of the DC supplies. The transformer has a total of three secondary windings, one of which is center tapped.

Three bridge rectifiers provide the necessary AC to DC conversion. CR106 and CR107 are connected in ordinary bridge-type configuration, but CR108 is actually used as two fullwave rectifiers to provide $\pm$15V.

Regulation is provided by IC regulators VR101,VR102, VR103 and VR104, which regulate the +5V digital, +5V analog, +15V analog, and -15V analog supplies respectively.

Filtering for each supply is provided both at the rectifier and regulator outputs. Since the 5V digital supply delivers the most current, its input filter capacitor has the highest value. Conversely, the requirements of the two 15V supplies is less stringent, so those filter capacitors have the smallest values.

6.6 MODEL 1950 AC/CURRENT OPTION

The Model 1950 option expands the capabilities of the Model 195A to include AC voltage and current and DC current measurements. For the following discussion, refer to schematic number 1950-116.

Current inputs are applied to the AMPS input. Current ranging is provided by R507 through R510. AC voltage is applied to the DC/AC HI input. Input switching is performed by relays K501 through K504 and FETs Q502, Q503, Q505, and Q506. These components are ultimately controlled by U504, which is an 8-bit shift register/latch. The latch is fed data from the microprocessor, which controls the Model 1950 much like the Model 195A input multiplexer is controlled.

U506 provides amplification for the AC input voltage, while C507 and C509 provide a means for trimming the high frequency response of the instrument when making AC measurements. K505 and K506 control the gain of U506, thus providing range switching. TRMS AC-DC conversion is performed by U507, which gives accurate TRMS conversion with a crest factor of 3.

6.7 CIRCUIT OPERATION DURING MEASUREMENTS

The following paragraphs describe circuit operation during DC voltage, resistance, and Model 1950 AC/current option measurements.

6.7.1 DC Voltage Measurement

General instrument configuration for DC voltage measurements is shown in Figure 6-8. The input signal is applied to the input switch, S103. Depending on the range, the voltage is coupled directly through a multiplexer FET, or through a 1000:1 or 100:1 attenuator to the input amplifier. This switching function is performed by K102.

Three sequential voltages must be applied to the A/D converter for a DC voltage measurements, including a zero (V_{ZERO}), the input signal voltage (V_{SIG}) and the -2V reference voltage (V_{REF}). Each signal is applied to the A/D converter for 16.66ms which then converts the signal so it can be stored in microcomputer memory.

The FET switching sequence is shown in Figure 6-9. Note that reading calculations are done at several phases during the input sequence.

Once the digitized values for each input signal are in memory, the microcomputer calculates the displayed or IEEE value from the following formula:

$$V = \frac{-2\ (V_{SIG} - V_{ZERO})}{(V_{REF} - V_{ZERO})}$$

It can be seen that the zero error is subtracted from both the signal and reference values, and the ratio is then taken. Multiplication by two is necessary because of the -2V reference source value.

6.7.2 Circuit Operation During Resistance Measurements

For resistance measurements, four inputs are used so the Model 195A can obtain a measurement through the use of ratiometric techniques.
These four inputs include:

1. Ohms Reference HI
2. Ohms Reference LO
3. Ohms Sense HI
4. Ohms Sense LO

The ratiometric technique is a mathematical process that compares two numbers and derives their ratio. In the Model 195A, this ratio is a voltage ratio that is created by a common current flowing through two resistors in series. The current passes through both a known internal reference resistance and the unknown resistance which is connected to the input

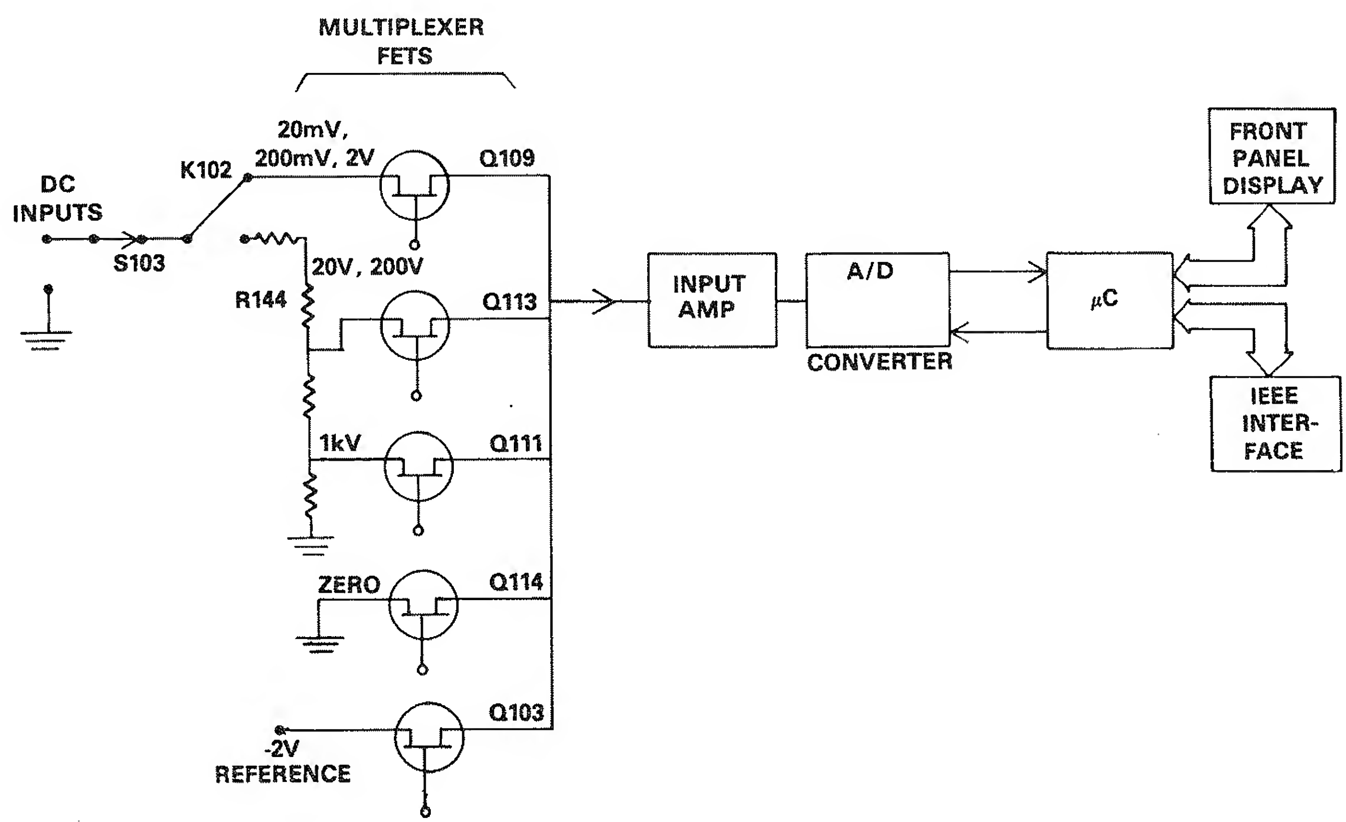


Figure 6-8. Circuit Operation During DC Voltage Measurements

terminals. The current through both resistors can then be determined by measuring the voltage drop across the known resistance and then calculating the current. Once the current and voltage associated with the known resistance are known, the unknown resistance value can be calculated.

Figure 6-10 shows a simplified schematic of the Model 195A configuration during resistance measurements. FET switches Q121 and Q122 select one of the two known resistors. A -2V ohms reference source is connected to one side of the known resistor, and the other side of the resistor is connected to the INPUT HI (VOLTS OHMS HI) terminal.

The FET switching sequences for the various ranges are shown in Figures 6-11 through 6-13. The sequences for the various ranges are similar, with the first two phases being the same in all cases.

As each FET is switched on, the voltage developed across that particular section of the voltage divider made up of the known resistor, the sense resistors, and the unknown resistance, is sampled. After A/D conversion, the digitized signal is stored in microcomputer memory. The final displayed value is then calculated using the information stored during each input phase.

6.7.3 Two- and Four-Terminal Resistance Considerations

The Model 195A is equipped to make automatic 2- or 4-terminal resistance measurements. Generally, 4-terminal measurements should be made on the 20Ω and 200Ω ranges because the relatively large output current can develop a significant voltage across the test leads, significantly affecting instrument accuracy.

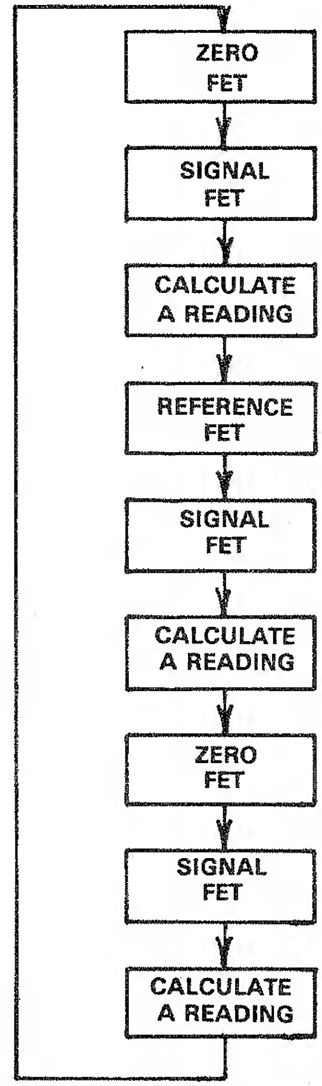


Figure 6-9. FET Switching Sequence During DC Voltage Measurements

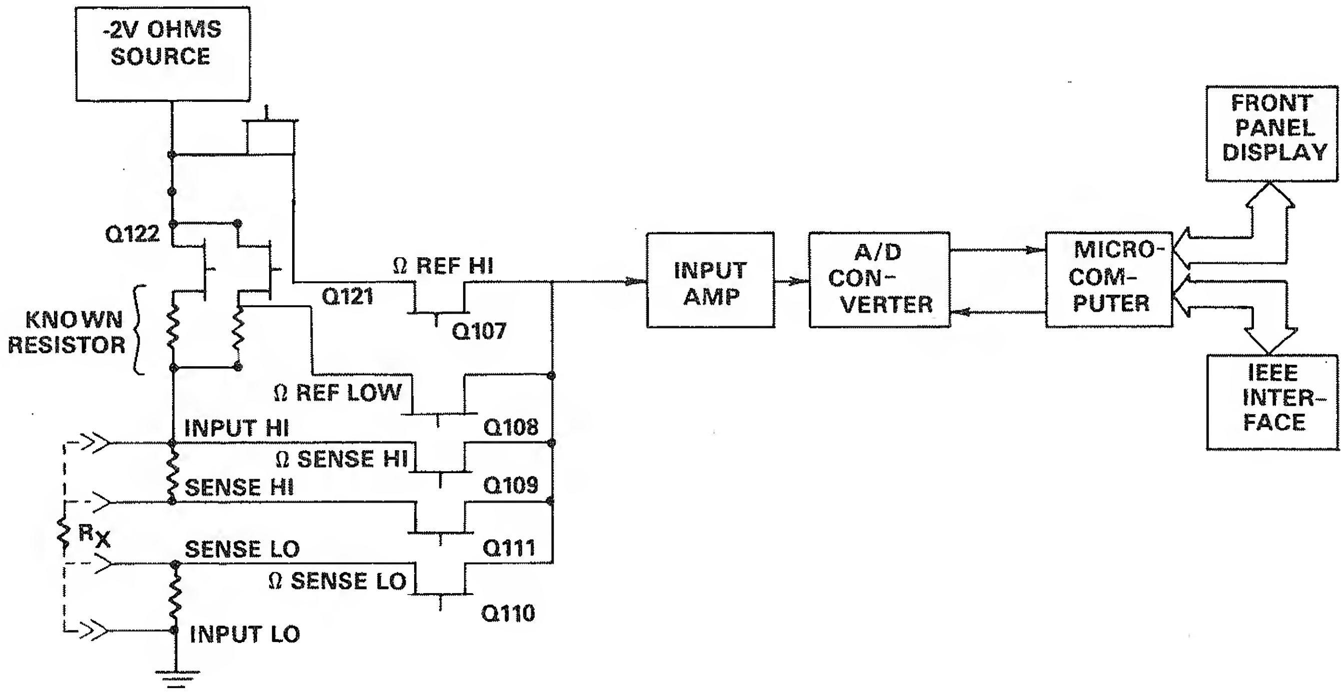


Figure 6-10. Resistance Measurement Simplified Circuit for 20-200kΩ Ranges

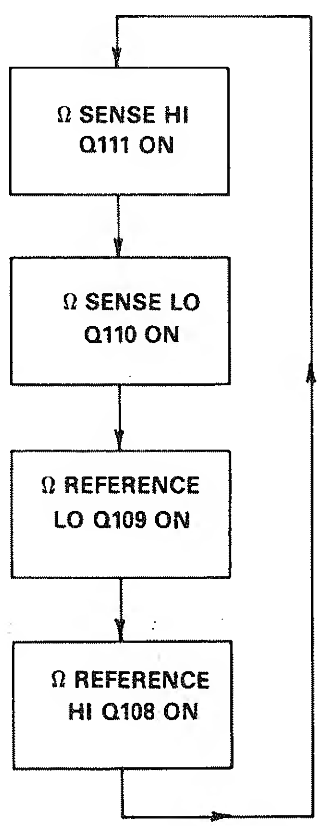


Figure 6-11. FET Switching Sequence for 20Ω, 200Ω and 2kΩ Ranges

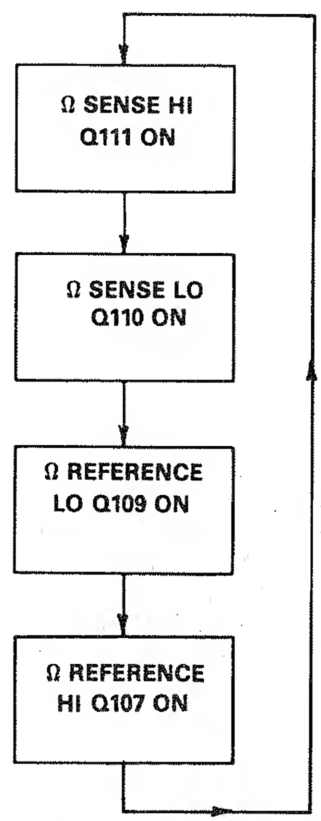


Figure 6-12. FET Switching Sequence for 20kΩ and 200Ω Ranges

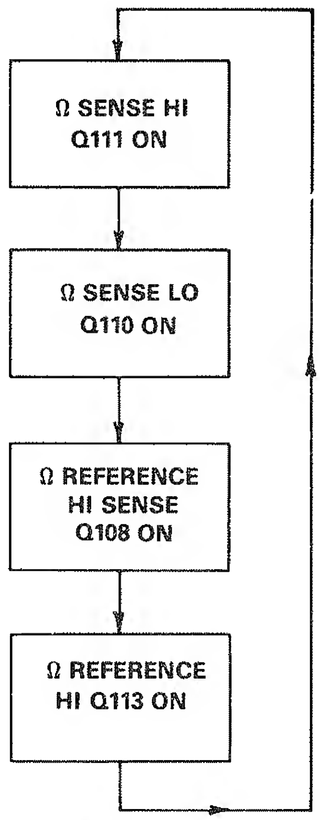


Figure 6-13. FET Switching Sequence for 2MΩ and 20MΩ Ranges

Figure 6-14 shows the equivalent circuit of the input circuit during 2-terminal resistance measurements. R_X is the unknown measured resistance, and R_1 and R_4 represents the test lead resistance. When in this mode, all the current flows through one set of test leads. If R_X ha a low value, the amount of voltage developed across the test leads can be significant. Since the voltage is sampled across the combined resistance of R_1, R_X and R_4, considerable error can be introduced into the reading.

By using a 4-terminal configuration, as shown in Figure 6-15, the error can be reduced considerably. Here, most of the current flows through the test leads represented by R_1 and R_4. Voltage sampling is done by connecting the second set of leads (represented by R_2 and R_3) to the unknown resistance. The amount of current through R_2 and R_3 is much smaller than the current through R_1 and R_4. Thus, the voltage seen by the instrument is much closer to the actual value across the measured resistance, reducing the error considerably.

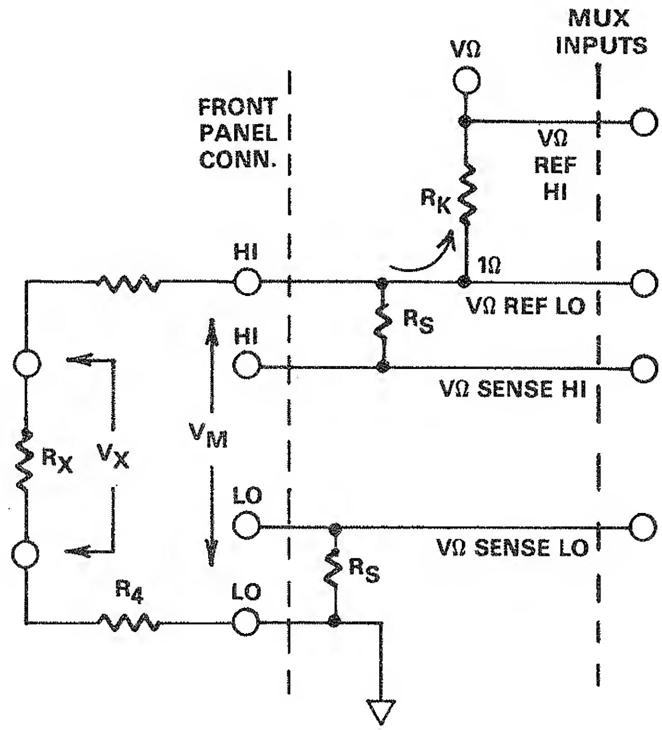


Figure 6-14. Input Configuration During 2-Terminal Measurements

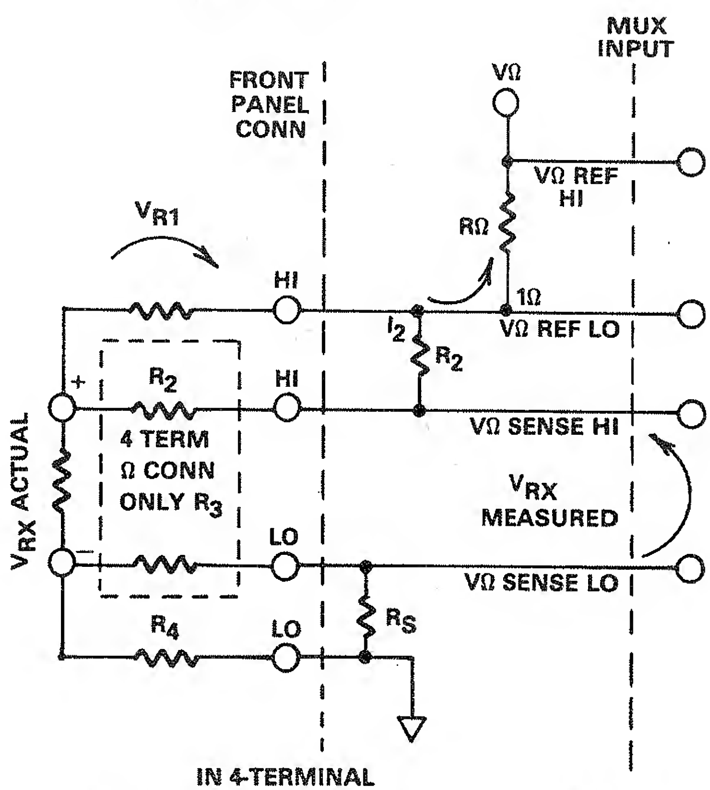


Figure 6-15. Input Configuration During 4-Terminal Measurements

6.7.4 Circuit Operation During Model 1950 Option Measurements

During AC voltage and AC and DC current measurements, the input signal is routed to the Model 1950 option for AC-to-DC conversion or current-voltage transformation. The Model 1950 converts these input signals into a 0 to 2VDC voltage usable by the Model 195A buffer amplifier and A/D converter.

Figure 6-16 shows instrument configuration during Model 1950 option measurements. The signal is applied to the Model 1950 where it is modified into the proper form. The output of the Model 1950 is then routed to Q102, the option sense FET.

As with the remaining measurements, option measurements are performed using a specific sequence. Figure 6-17 shows the FET switching sequence for all option measurements. During the first phase, Q102 is on, which means that the option output signal is applied to the input amplifier. During the second and fourth phase, the zero FET is on, and the -2V reference FET is on during the third phase of the input cycle.

During each of the four phases, the A/D converter converts the signal into a form usable by the microcomputer. Once each of the four signal phases are stored in memory, the microcomputer then takes the information and calculates the final reading.

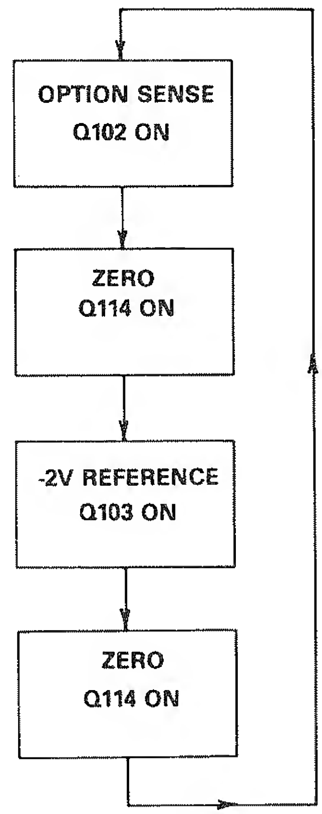


Figure 6-17. FET Switching Sequence for Model 1950 Option Measurements

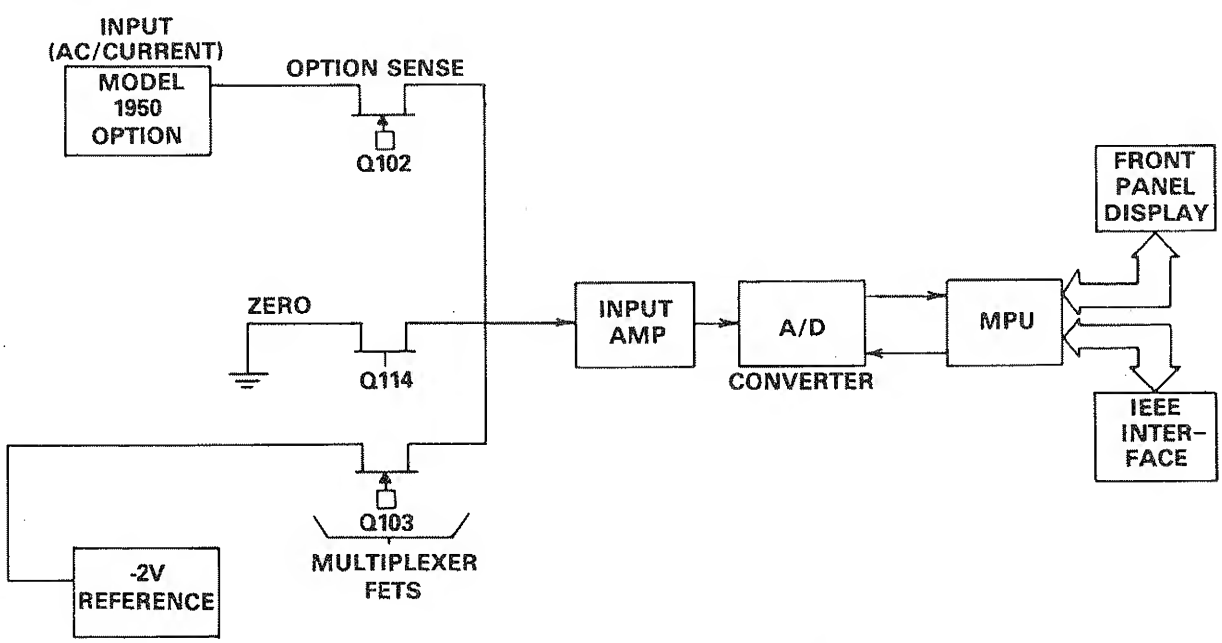


Figure 6-16. Instrument Configuration During Model 1950 Measurements

6.8 TEMPERATURE MEASUREMENT

Model 195A temperature readings are based on the 4-wire resistance measurements of a platinum RTD (resistance temperature detector). As the probe temperature rises, its resistance increases as well, although not in a precisely linear manner.

In the Model 195A, these resistance measurements are made in the normal manner, but during the measurement process, thermal voltages generated by dissimilar electrical contacts are cancelled out. This cancellation is achieved by making two measurements: the first is the voltage across the OHMS SENSE HI and LO terminals with current flowing through the RTD probe; the second measurement is made with no current flowing through the probe. These voltage measurements are then used by the microcomputer to calculate the temperature. Because the RTD current has a 25% duty cycle, probe heating is reduced; also, the off cycle allows thermal voltages to be measured.

6.8.1 RTD Resistance Measurement

Figure 6-18 shows a simplified schematic of the Model 195A and RTD probe during temperature measurements. V_1 through V_4 represents thermal contact voltages generated by dissimilar metals. V_{RTD} is the voltage developed across the probe when current I is flowing. The remaining circuitry to the right is the normal Model 195A input and multiplexer circuitry.

When current is flowing through the RTD probe, the voltage, as seen at the OHMS SENSE HI and LO terminals, is:

$$V_{HI} - V_{LO} = V_2 + V_{RTD} + V_5 + V_3$$

With no current flowing, the voltage between these two terminals is:

$$V_{HI} - V_{LO} = V_2 + V_5 + V_3$$

Since the voltage is measured at the OHMS SENSE terminals, V_1 and V_4 are insignificant.

The resistance value of the probe can then be calculated as follows:

$$R_{RTD} = R_{REF}\, V_{RTD}/(V_{REF\ HI} - V_{REF\ LO})$$

6.8.2 FET Switching Sequence

As with all other Model 195A measurements, RTD resistance measurements are performed by switching various input FETs on and off. Figure 6-19 shows the general switching sequence for RTD measurements. Figure 6-20 shows the flow chart for the switching sequence. Each FET is assumed to be on when a positive pulse occurs.

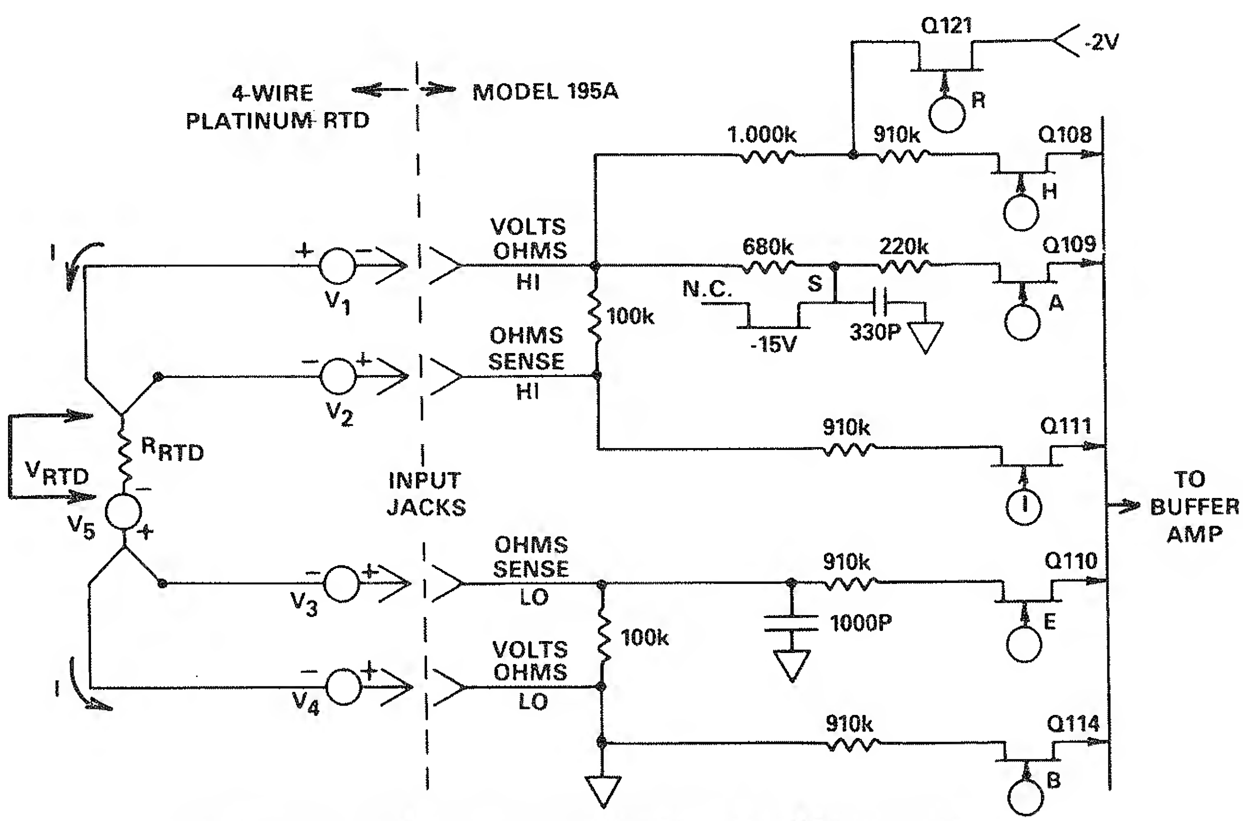


Figure 6-18. Simplified Circuit of RTD Resistance Measurement

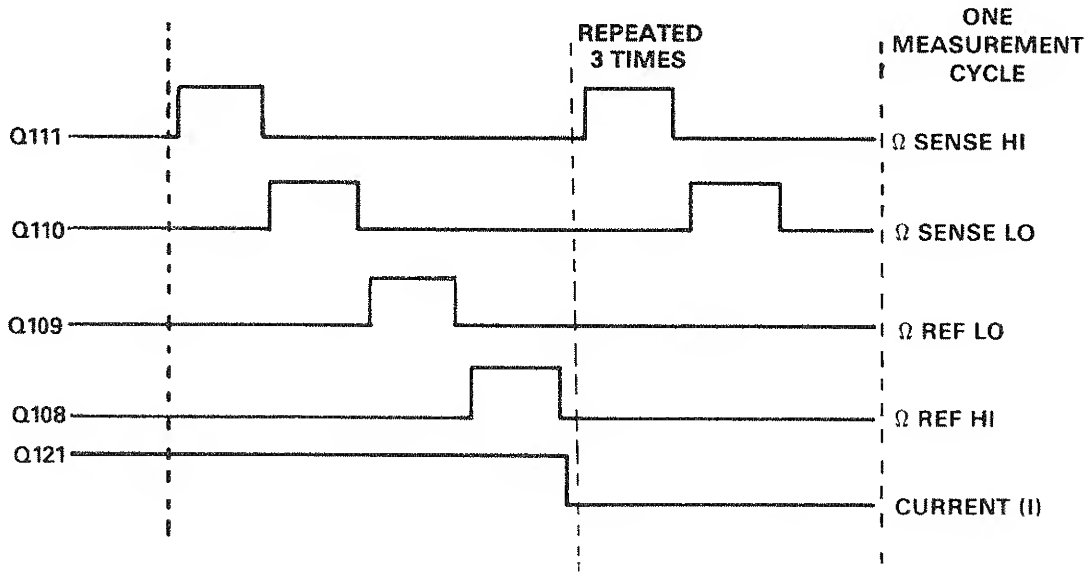


Figure 6-19. FET Switching Sequence

During the first phase of the measurement cycle, Q121 is turned on, causing current to flow through the RTD. Q111, Q110, Q109 and Q108 are then turned on in sequence to measure the voltage across the RTD with current flowing through it. During the second phase, Q121 is turned off, and Q111 and Q110 are turned on in sequence to perform the necessary measurements for the last phase. This last phase is repeated three times to provide the necessary duty cycle.

6.8.3 Reading Calculations

Once the measurements are stored within the microcomputer, it is a simple matter to calculate the final reading. Above 0°C, these calculations are performed using the following relationships:

$$T_C = \frac{-A + \sqrt{A^2 - 4B[1 - R_t/R_0]}}{2B}$$

Where:

$A = (1 + \alpha/100)$

$B = -\alpha\,\delta\,(10^{-4})$

α and δ are given constants

R_0 is the probe resistance at 0°C

R_t is the probe resistance at the measured temperature

$T_F = 9/5T_C + 32$

Example:
Assume the Model 195A is used with a probe conforming to the DIN 43 760 standard and is measuring a temperature of 210°C. At this temperature with this probe, the values are:

$R_0 = 100.00\Omega$

$R_t = 179.51\Omega$

$\alpha = 0.00385$

$\delta = 1.502$

$A = 0.00385[1 + (1.502/100)] = 0.0039078$

$B = -(10^{-4})\ (0.00385)\ (1.502) = 5.7827 \times 10^{-7}$

$$T_C = \frac{0.0039078 + \sqrt{(0.0039078)^2 - 4(-5.7827 \times 10^{-7})[1-(1-79.51/100)]}}{2(-5.7827 \times 10^{-7})}$$

$T_C = 210°C$

$T_F = (9/5)\ (210) + 32 = 410°F$

Below 0°C, two additional constants, A4 and C4, are used in a fourth order polynominal to calculate the temperature reading. These constants are not directly programmable, but their values will change in accordance with the selected standard (DIN 43 760 or IPTS-68), which can be programmed during the calibration procedure as described in paragraph 5.2.4.

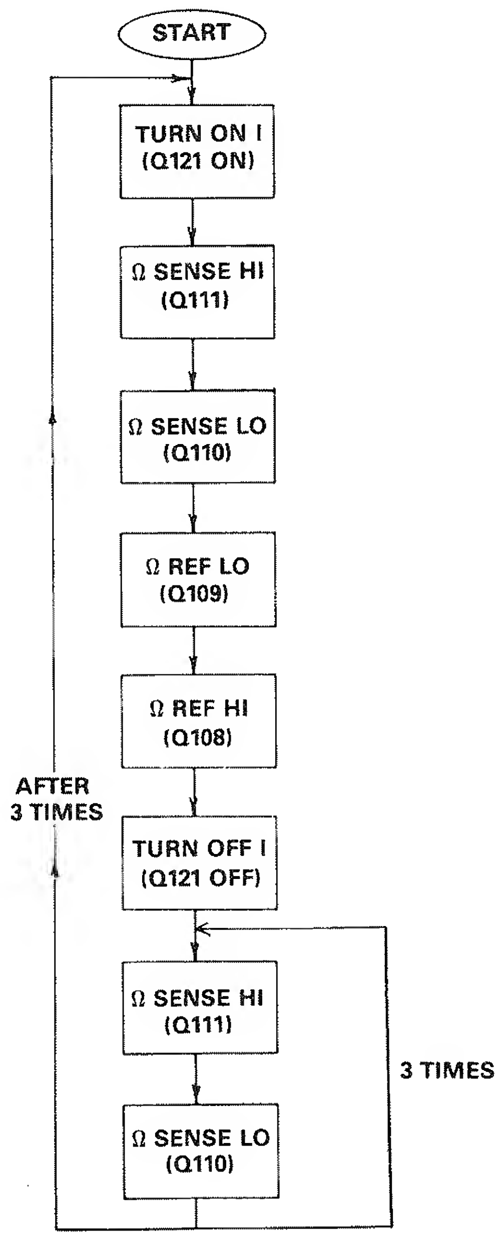


Figure 6-20. FET Switching Sequence for RTD Resistance Measurements

SECTION 7
MAINTENANCE

7.1 INTRODUCTION

This section contains information necessary to maintain, calibrate and, troubleshoot the Model 195A DMM and the Model 1950 AC current option. Fuse replacement procedures, line voltage selection, and Model 1950 installation procedures are also included.

WARNING
The procedures described in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps covered in this section may expose the individual to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.

7.2 LINE VOLTAGE SELECTION

The Model 195A may be operated from either 105-125V or 210-250V 50-400Hz power sources. A special transformer may be installed for 90-110V and 195-235V ranges. The instrument was shipped from the factory set for an operating voltage marked on the rear panel immediately above the power line receptacle. To change the line voltage, proceed as follows:

1. Remove the top cover as described in the disassembly instructions in paragraph 7.7.

WARNING
Disconnect the Model 195A from the power line and all other sources before removing the top cover.

2. Using a flat-blade screwdriver, place the line voltage selection switch in the desired position. The line voltage selection switch is located near the power transformer. See Table 7-1 for the correct position.
3. Install a power line fuse consistent with the operating voltage. See paragraph 7.3.1.

Table 7-1. Line Voltage Selection

Power Line Voltage	Line Frequency	Voltage Selection Switch Position
105-125V	50-400Hz	115V
210-250V	50-400Hz	230V
90-110V*	50-400Hz	115V
195-250V*	50-400Hz	230V

*Requires special power transformer.

CAUTION
The correct fuse type must be used to maintain proper instrument protection.

4. Mark the selected voltage on the rear panel with a water-soluble marking pen for future reference.
5. Replace the top cover and connect the instrument to the power line.

7.3 FUSE REPLACEMENT

The Model 195A has two fuses for protection in case of overload. The line fuse protects the line power input of the instrument and the amps fuse protects the Model 1950 option from excessive current. These fuses may be replaced by using the procedures described in the following paragraphs.

WARNING
Disconnect the instrument from the power line and from other equipment before replacing fuses.

7.3.1 Line Fuse

To replace the line fuse, proceed as follows:

1. Turn off the power and disconnect the line cord from the power source.
2. Place the end of a flat-blade screwdriver into the slot in the LINE FUSE holder on the rear panel. Push in and rotate the fuse carrier one-quarter turn counterclockwise. Release pressure on the holder and its internal spring will push the fuse and the carrier out of the holder.
3. Remove the fuse and replace it with the proper type using Table 7-2 as a guide.

CAUTION
Do not use a fuse with a rating higher than specified or instrument damage may occur. If the instrument persistently blows fuses, a problem may exist within the instrument. If so, the problem must be rectified before continuing operation.

Table 7-2. Line Fuse Selection

Power Line Voltage	Fuse Type	Keithley Part Number
90-125V	3/16A, 250V, 3AG	FU-29*
195-250V	1/10A, 250V, 3AG	FU-40*
90-125V	3/16, 5mm	FU-32**
195-250V	1/10A, 5mm	FU-33**

*American Units
**European Units

4. To install the new fuse and carrier into the holder, reverse the procedure in step 2.

7.3.2. Amps Fuse

The amps fuse protects the Model 1950 option from an input current greater than 2A. To replace the amps fuse, perform the following steps:

1. Turn off the power and disconnect the instrument from the power line and from other equipment.
2. Place the end of a flat-blade screwdriver into the slot in the AMPS FUSE holder on the rear panel. Press in slightly and rotate the fuse carrier one-quarter turn counterclockwise. Release pressure and remove the fuse carrier and the fuse.
3. Remove the defective fuse and replace it with the following type: 2A, 250V, 3AG, normal-blow Keithley part number FU-13, or equivalent (American units) or 2A normal blow, 5mm FU-48 (European units).

CAUTION

Use only the recommended fuse type. If a fuse with a higher current rating is installed, instrument damage may occur.

4. To replace the fuse carrier with the fuse, reverse the procedure in step 2.

7.4 MODEL 1950 AC/AMPS OPTION INSTALLATION

The Model 1950 AC/Amps Option expands the capabilities of the Model 195A by allowing it to measure AC voltage and AC and DC current. If purchased with the Model 195A, the Model 1950 will be factory installed; however, the instrument may be easily upgraded in the field by installing the Model 1950 option as follows:

NOTE

After the Model 1950 is installed, the AC volts, and AC and DC current ranges must be calibrated.

1. Remove the top cover of the instrument as described in the disassembly instructions in paragraph 7.7.

WARNING

Disconnect the line cord and test leads from the instrument before removing the top cover.

2. Remove the two screws on the outer edge of the shield on the mother board. Do not remove the screw near the center of the shield.
3. Position the Model 1950 on top of the shield as shown in Figure 7-1. Line up the holes at the outer edge of the Model 1950 with the holes in the shield.
4. Secure the Model 1950 with the long screws provided with the accessory. These screws fit down through the option, shield, spacers, and mother board into the case bottom. Tighten the screws securely, but be sure not to over-tighten them.
5. Plug the ribbon connector into the DIP receptacle on the mother board next to the power transformer. Be sure that pin 1 of the connector lines up with pin 1 of the receptacle as shown in Figure 7-1.
6. Remove the jumpers between the BLU and BLK, and RED and YEL terminals on the mother board.
7. Connect the red, yellow, blue, black, and white wires to the proper terminals on the mother board. Each terminal on the board is marked with the color of the wire that is to be connected.
8. Replace the top cover.
9. Turn on the power and program the Model 195A for Model 1950 operation as follows:
   A. Press PRGM. This instrument will display the following message:

Pro ?

   B. Press 8. The instrument will briefly display the program number:

Pro 8

   C. Press the minus (-) button. If the Model 1950 option operation was disabled, it will now be enabled and the following message will be displayed:

AC OP

   D. If the Model 1950 operation was previously enabled, it will now be disabled, and the following message will be displayed:

no OP

   E. To enable the Model 1950 option at this point press the (-) button again.
   F. Exit program 8 by pressing PRGM and 0 in sequence.
10. Perform the NVRAM storage sequence as follows:
   A. Press PRGM. The instrument will display a prompt for a program number.

Pro ?

   B. Press 1. The program number will be briefly displayed:

Pro 1

   C. The following prompt will then be displayed:

Stor ?

   D. To perform NVRAM storage, press ENT. If the storage is successful, the instrument will return to normal operation.
   E. If the calibration jumper has been removed (see paragraph 7.5.9), storage will not take place, and the following message will be displayed:

noStr

NOTE
The instrument must be momentarily powered down for option programming to take effect.

11. Calibrate the AC volts and AC and DC current ranges as described in paragraph 7.5

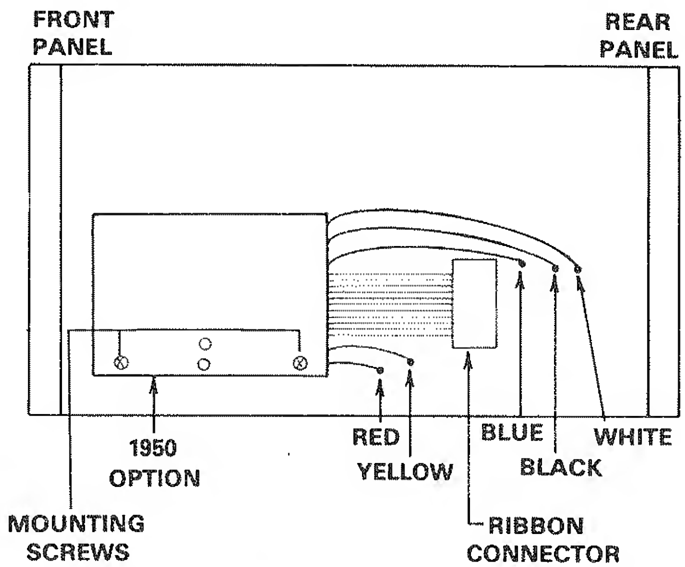


Figure 7-1. Model 1950 Installation

7.5 CALIBRATION

A unique feature of the Model 195A is its front panel calibration capability. No longer is instrument calibration a long, time-consuming operation. Instead, the technician need only connect an appropriate calibration signal to the instrument and run front panel Progam 5, which is the digital calibration program. Once the calibration constants are stored in the non-volatile RAM, the microprocessor can use this information to make necessary adjustments during future measurements. In this manner, a high-degree of accuracy is maintained with a minimum of instrument maintenance.

Calibration of the volts, ohms and current ranges should be performed every 12 months, or if the performance verification procedures in Section 5 show that the Model 195A is out of specification. The temperature calibration procedure may be used to change instrument calibration to another standard, or to optimize instrument performance for use with a specific probe. If any of the calibration procedures in this section cannot be performed properly, refer to the troubleshooting information in this section. If the problem persists, contact your Keithley representative or the factory for further information.

NOTES:
1. The Program 5 keystroke sequence is described fully in paragraph 3.5.6.
2. Calibration must be performed in the order listed: DCV, Ohms, ACV, Current, Temperature.
3. Calibration may also be performed over the IEEE bus; see paragraph 4.10.15.

7.5.1 Recommended Calibration Equipment

Recommended calibration equipment is listed in Table 7-3. Alternate equipment may be used as long as equipment accuracy is at least as good as the specifications listed in Table 7-3.

7.5.2 Environmental Conditions

Calibration should be performed under laboratory conditions having an ambient termperature of 23±1°C and a relative

Table 7-3. Recommended Test Equipment For Calibration

Description	Specifications	Manufacturer and Model
DC Voltage Calibrator	20mV, 200mV, 2V, 20V, 200V, 1100V ranges ±0.005% accuracy.	Fluke 5100B
AC Voltage Calibrator	20mV, 200mV, 2V, 20V 200V, 1100V ranges ±0.05% accuracy.	Fluke 5100B
DC Current Calibrator	200μA, 2mA, 20mA, 200mA, 2A ranges ±0.025% accuracy.	Fluke 5100B
AC Current Calibrator	200μA, 2mA, 20mA 200mA, 2A ranges ±0.07% accuracy	Fluke 5100B
Decade Resistor	19Ω, 190Ω, 1.9kΩ, 19kΩ, 190kΩ, 1.9MΩ, 10MΩ ±0.01% accuracy	ESI RS725

humidity of less than 70%. If the instrument has been subjected to temperatures outside this range, or to higher humidity, allow at least one additional hour for the instrument to stabilize before beginning the calibration procedure.

7.5.3 Warm-Up Period

Most equipment is subject to at least a small amount of drift when it is first turned on. To ensure long-term calibration accuracy, turn on the power to the Model 195A and allow it to warm-up for at least two hours before beginning the calibration procedure.

7.5.4 DC Voltage Calibration

Calibrating the instrument on the DC voltage ranges involves connecting a precise DC calibration voltage to the instrument and then running Program 5 as follows:

1. Select the DC volts function and connect the calibration source to the instrument as shown in Figure 7-2.

CAUTION
Do not exceed 1000V between the VOLTS OHMS terminals or instrument damage may occur.

2. Use the zero mode for calibration on the DCV, Ohms and DCA ranges when necessary.
3. Select the range to be calibrated and set the calibrator to the corresponding output listed in Table 7-4.
4. Enter Program 5 by pressing the PRGM and 5 buttons in sequence.
5. Key in the corresponding calibration value if different from the prompted value from Table 7-5 and press the ENT button, or press PRGM to abort the calibration sequence; this will not affect the previous calibration value. For example, on the 20V range, the required value is 19.0000+0.
6. Repeat the procedure for each range listed in Table 7-4.

NOTE
For permanent storage of calibration constants, Program 1 must be used as described in paragraph 7.5.9. The PRGM light will flash until NVRAM storage is successfully performed.

Table 7-4. DC Voltage Calibration Parameters

Step	Range	Calibration Voltage	Program 5 Parameter
1	20mV	19.0000mV	19.0000 −3
2	200mV	190.000mV	190.000 −3
3	2 V	1.90000 V	1.90000 +0
4	29 V	19.0000 V	19.0000 +0
5	200 V	190.000 V	190.000 +0
6	1000V	990.00 V	990.00 +0

Table 7-5. Parameters for Resistance Calibration

Step	Range	Calibration Resistance Value	Program 5 Parameter
1	20 Ω	19 Ω	19.0000 +0
2	200 Ω	190 Ω	190.000 +0
3	2 kΩ	1.9 kΩ	1.90000 +3
4	20 kΩ	19 kΩ	19.0000 +3
5	200 kΩ	190 kΩ	190.000 +3
6	2MΩ	1.9MΩ	1.90000 +6
7	20MΩ	10MΩ	10.0000 +6

7.5.5 Resistance Calibration

Resistance calibration is done by connecting a precise, known resistance to the VOLTS OHMS terminals and running Program 5 as follows:

1. Select the resistance function by pressing the OHMS button.

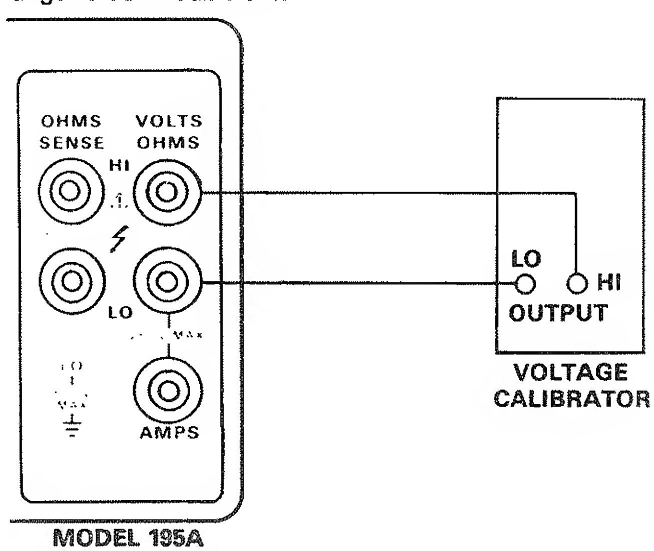


Figure 7-2. Voltage Calibration Connections

2. Connect the calibration resistance to the VOLTS OHMS terminals. See Table 7-5 for recommended values. Use the 4-terminal connections shown in Figure 7-3 for calibration on the 20Ω and 200Ω ranges. The 2-terminal connections shown in Figure 7-4 may be used for all ranges if zero is left enabled.
3. For calibration of the 20Ω and 200Ω ranges, enable the zero mode by first shorting the leads together and then pressing the ZERO button.
4. Select the corresponding range listed in Table 7-5.
5. Enter Program 5 by pressing the PRGM and 5 buttons in sequence. Enter the required resistance parameter listed in Table 7-5. For example, on the 200kΩ range, 190.000+3 will be entered. Press ENT to enter the calibration value.
6. Repeat the procedure for each of the seven resistance ranges.

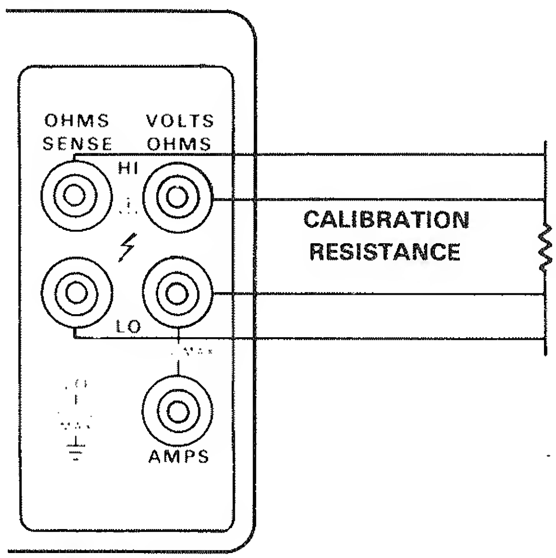


Figure 7-3. Connections for Calibration of 20Ω and 200Ω Ranges

NOTE
For non-volatile storage of resistance calibration constants, front panel Program 1 must be used as described in paragraph 7.5.9. The PRGM light will flash until NVRAM storage is successfully performed.

7.5.6 AC Voltage Calibration (With Model 1950 Option)

To perform AC voltage calibration, connect a precise AC voltage source to the VOLTS OHMS terminals and use Program 5 as follows:

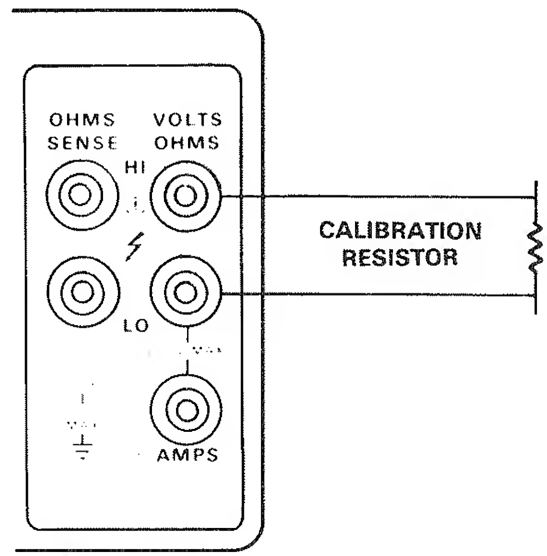


Figure 7-4. Connections for Calibration of 2kΩ Through 20MΩ Ranges

1. Connect the calibrator to the instrument as shown in Figure 7-2. Set the calibrator frequency to 1kHz.

CAUTION
Do not exceed 700V RMS, 1000V peak between the VOLTS OHMS terminals.

2. Select the AC volts function with the VOLTS and AC buttons.
3. Select the range to be calibrated and set the calibrator output to the corresponding value listed in Table 7-6.

NOTE
Calibration of the 2VAC range must be done first at the two points listed in the table to achieve rated accuracy. Do not use ZERO when calibrating ACV or ACA.

4. Enter Program 5 by pressing the PRGM and 5 buttons in sequence.
5. Enter the calibration value listed in Table 7-6. For example, on the 200mV range, a value of 190.000-3 will be entered. Press ENT to enter the calibration constant into the program.
6. Repeat the above procedure for each range.

NOTE

Use Program 1 to store AC calibration constants in non-volatile RAM. See paragraph 7.5.9. The PRGM LED will flash until NVRAM storage is performed.

7. Frequency compensation may now be performed as follows:
   A. Place the instrument on the 200VAC range and set the calibrator output to 100.00V at 1kHz. The reading should be within the limits listed in Table 7-7. If not, repeat the above calibration procedure on the 200V range. Press zero.
   B. Switch the calibrator frequency to 20kHz. Adjust C507 on the Model 1950 (see Figure 7-5) so that the display reads 0.0000±2 counts.

NOTE

Use a non-metallic adjustment tool when adjusting either C507 or C509. Do not remove the shield when making these adjustments.

   C. Disable ZERO and set the calibrator output to 1.0000V, 200Hz; switch the Model 195A to the 2VAC range. Enable ZERO; adjust C509 on the Model 1950 so that the displayed reading is 0.0000V±2 counts.

Table 7-6. AC Voltage Calibration Parameters

Step	Range	Calibrator Voltage	Program 5 Parameter
1	2 V*	1.00000 V	1.00000 +0
2	2 V*	0.10000 V	0.10000 +0
3	200mV	190.000mV	190.000 −3
4	20 V	19.0000 V	19.0000 +0
5	200 V	190.000 V	190.000 +0
6	700 V	690.00 V	690.00 +0

*Instrument will prompt for two sets of inputs; 2V range calibration must be done first at these two points in sequence for rated accuracy.

7.5.7 AC and DC Current Calibration (With Model 1950 Option)

Current calibration need only be performed on the DC ranges. Once DC calibration is completed, the AC current ranges are automatically calibrated. AC ranges may be directly calibrated, if desired, but these parameters will not be stored in NVRAM.

NOTE

Current calibration depends on proper DCV and ACV calibration.

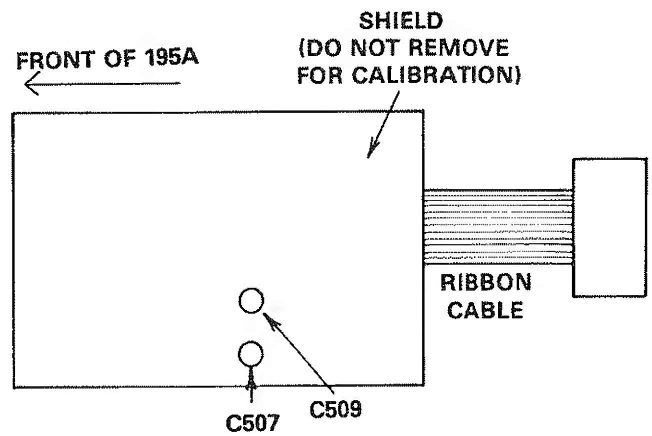


Figure 7-5. Location of Frequency Compensating Capacitors on Model 1950

Proceed as follows:

1. Connect the calibrator to the Model 195A as shown in Figure 7-6.

CAUTION

Do not exceed 2A input current or the option fuse will blow.

2. Set the Model 195A to the range to be calibrated and set the calibrator to the corresponding value listed in Table 7-8.
3. Press the PRGM and 5 buttons in sequence and enter the calibration value listed in the table. Press ENT to enter the parameter.
4. Repeat the procedure for each of the six current ranges.

Table 7-7. Model 1950 Frequency Compensation Parameters

Range	Calibrator Voltage	Calibrator Frequency	Allowable Range	Comments
200VAC	100.000V	200Hz	99.300 to 100.700V	200Hz reference
200VAC	100.000V	20kHz	0.0000±2 counts	Adjust C507 with ZERO enabled.
2VAC	1.00000V	200Hz	0.993V to 1.007V	200Hz Reference
2VAC	1.0000V	20kHz	0.0000±2 counts	Adjust C509 with ZERO enabled.

NOTE

For non-volatile storage of calibration parameters, use Program 1 as described in paragraph 7.5.9.

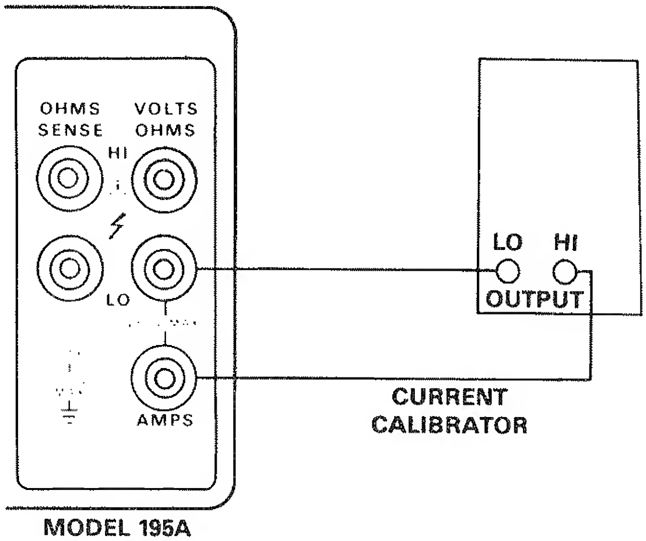


Figure 7-6. Current Calibration Connections

Table 7-8. Current Calibration Parameters

Step	Range	Calibrator Output	Program 5 Parameter
1	20 μA	19.0000μA	19.0000 −6
2	200 μA	190.000μA	190.000 −6
3	2mA	1.90000mA	1.90000 −3
4	20mA	19.0000mA	19.0000 −3
5	200mA	190.000mA	190.000 −3
6	2 A	1.90000 A	1.90000 +0

7.5.8 Temperature Calibration

Temperature calibration is performed by placing the instrument in the temperature mode (Program 6) and entering front panel Program 5. The basic procedure is similar to that used for calibrating other instrument functions.

NOTE

Proper temperature calibration requires that all other functions be properly calibrated (especially the 200Ω and 2kΩ ranges).

During the calibration procedure, the instrument will prompt for a number of constants. Table 7-9 summarizes prompt messages. Along with each prompting message, the display will show either the factory value or the previously programmed value for each constant. The inputs required for calibration include:

Table 7-9. Calibration Procedure Messages

Message	Purpose	Remarks
ALPHA	Prompts for alpha constant.	Default alpha value displayed after prompt (DIN 43 760 = 0.00385, IPTS-68 = 0.00392)
dELtA	Prompts for delta constant.	Default delta value displayed after prompt. (DIN 43 760 = 1.502, IPTS-68 = 1.49633)
t=0°C	Prompts for probe resistance at 0°C.	Default probe resistance value displayed after prompt.
n Std ?	Prompts for DIN or NBS IPTS-68 standard.	Programmed standard displayed with prompt.
3or4t 4	Prompts for 3- or 4-wire probe operation.	Programmed operating mode displayed with prompt.
CAL	Shows temperature calibration in progress.	

1. Alpha—Used for reading calculations above 0°C (for DIN 43 760 standard, alpha = 0.00385; for IPTS-68 standard, alpha = 0.00392).
2. Delta—Also used for reading calculations above 0°C (for DIN 43 760, delta = 1.502; for IPTS-68 delta = 0.00392).
3. t = 0°C-the probe resistance at 0°C.
4. DIN or NBS (IPTS-68) standard-Used to select appropriate A4 and C4 constants for better conformity below 0°C.
5. 3- or 4-terminal operating mode selection.

The Model 195A is factory calibrated to conform to the DIN 43 760 standard. The calibration procedure may be used to change instrument calibration to another standard, or to optimize instrument performance for use with a specific probe. To calibrate temperature follow the temperature calibration procedure found in paragraph 3.5.6.

7.5.9 Non-Volatile Storage of Calibration Constants

Once all the calibration constants have been entered with Program 5, Program 1 must be used to store them in NVRAM or they will be lost when the instrument is powered down. To perform NV storage, proceed as follows:

1. Press the PRGM and 1 buttons in sequence. The instrument will ask if storage is desired as follows:

   Stor?

2. To perform storage, press ENT. If the storage is successful, the instrument will return to normal operation.
3. If the calibration jumper has been removed (see paragraph 7.5.10), storage will not take place, and the following message will be displayed:

   noStr

NOTES:
1. Program 1 may be aborted at step 2 by pressing PRGM.
2. Only those calibrated constants entered during the present power-up cycle will be altered.

7.5.10 Calibration Jumpers

Non-volatile storage can be disabled to avoid inadvertently changing instrument calibration or operating parameters. These two jumpers, which are located on the mother board as shown in Figure 7-7, can modify non-volatile storage as follows:

1. Removing the CAL DISABLE jumper completely disables non-volatile storage whether storage is attempted from the front panel or over the IEEE bus.
2. The IEEE/FRONT PANEL jumper controls IEEE non-volatile storage. In the FRONT PANEL position, storage may be performed only from the front panel. In the IEEE position, storage may be performed from either the front panel or the IEEE bus.

3. If front panel only is selected, the ENT button must be held in for the duration of the storage cycle.

NOTE

The calibration jumpers affect all NV storage, including IEEE primary address, line frequency, calibration constants, and Model 1950 option status.

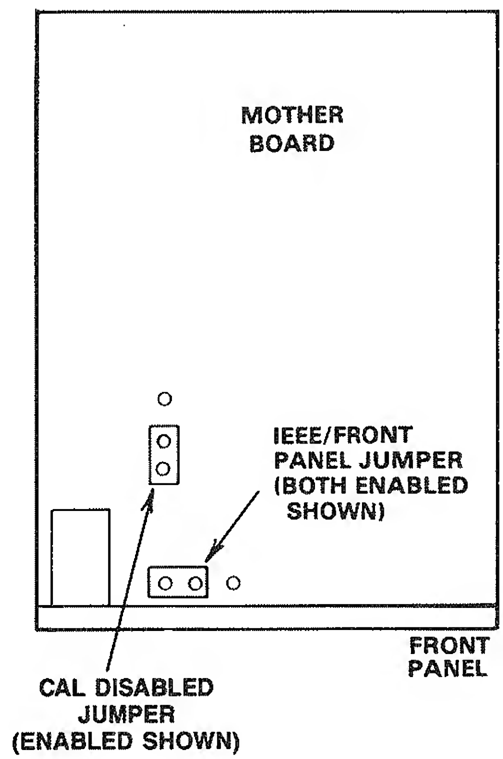


Figure 7-7. Calibration Jumper Locations

7.6 SPECIAL HANDLING OF STATIC SENSITIVE DEVICES

CMOS devices are designed to operate at very high impedance levels for low power consumption. As a result, any normal static charge that builds up on your person or clothing may be sufficient to destroy these devices if they are not handled properly. Table 7-10 lists the static sensitive device in the Model 195A. When handling these devices, use precautions below to avoid damaging them.

1. The ICs listed in Table 7-10 should be transported and handled only in containers specially designed to prevent static build-up. Typically, these parts will be received in static-protected containers of plastic or foam. Keep these devices in their original containers until ready for installation.
2. Remove the devices from their protective containers only

at a properly grounded work station. Also ground yourself with a suitable wrist strap.

3. Handle the devices only by the body; do not touch the pins.
4. Any printed circuit board into which the device is to be inserted must also be grounded to the bench or table.
5. Use only anti-static type solder suckers.
6. Use only grounded soldering irons.
7. Once the device is installed on the PC board, the device is normally adequately protected, and normal handling may resume.

Table 7-10. Static-Sensitive Devices

Schematic Designation	Keithley Part Number
Q102-Q103	TG-139
Q108-Q114	TG-139
Q124	TG-139
U101, U102	IC-250
U107	LSI-50
U108	LSI-28
U110	LSI-51
U111	LSI-30
U112	LSI-52
U115	IC-280
U118	LSI-49
U121	IC-106
U122	IC-197
U123	IC-138
U124	IC-324
U125	IC-203
U129	IC-251
U135	IC-135
U140	IC-251
U504*	IC-251

*On Model 1950 option .

7.7 DISASSEMBLY INSTRUCTIONS

If it is necessary to troubleshoot the instrument or replace a component, use the following disassembly procedure:

1. Remove the top cover as follows:

WARNING
Disconnect the line cord and test leads from the instrument before removing the top cover.

A. Remove the two screws that secure the top cover to the rear panel.
B. Grasp the top cover at the rear and carefully lift it off the instrument. When the tabs at the front of the cover clear the front panel, the cover may be pulled completely clear.
C. When replacing the cover, reverse the above procedure; be sure to install the tabs at the front of the cover into the front panel before completely installing the cover.

2. If the Model 1950 option is installed, it can be removed from the instrument as follows:

NOTE
Recalibration of the AC and current ranges will be necessary if the Model 1950 option is removed.

A. Disconnect the ribbon connector from its mating receptacle on the mother board.
B. Disconnect the remaining five wires from the mother board.
C. Remove the two screws at the outer edge of the shield; carefully pull the option clear and set it aside.

3. If the mother board is to be removed from the case, proceed as follows:

NOTE
If the Model 1950 option is installed, it should be removed before attempting to remove the mother board.

A. Remove the two screws securing the shield to the mother board (these screws will already have been removed with the Model 1950 option).
B. Remove the four remaining screws securing the mother board to the case.
C. Disconnect the front and rear panel leads going to the INPUTS switch (mark the wires for proper installation).
D. Disconnect the wires going to the VOLTMETER COMPLETE and EXTERNAL TRIGGER jacks at the mother board end (mark their positions first for reference).
E. Disconnect the display board ribbon connector from its jack.
F. Remove the two screws securing the IEEE-488 connector to the rear panel. Remove the screws securing the rear panel to the case.
G. Remove the remaining screw from the shield and remove the shield.
H. Grasp the rear panel and pull up and back until the on-off switch clears the front panel; then pull straight up to remove the mother board completely.
I. To install the mother board, reverse the above procedure. Be sure to connect all wires to the appropriate terminals. Also, when installing the shield, be sure not to pinch any wires between the shield and the board.

4. The display board can now be removed as follows:
A. Remove the front panel buttons from the switches.
B. Remove the two small screws that secure the display board to the front panel.
C. Tilt the top of the board away from the front panel slightly and pull the board up until it is clear of the case.
D. To install the display board, reverse the above procedure; be sure the board is fitted properly into the

slots in the case bottom before lining up the top screw holes.

7.8 TROUBLESHOOTING

The troubleshooting instructions contained in this section are intended for qualified personnel having a basic understanding of analog and digital circuitry. The individual should also be experienced at using typical test equipment as well as ordinary troubleshooting procedures. The information presented here has been written to assist in isolating a defective circuit or circuit section; isolation of the specific component is left to the technician.

7.8.1 Recommended Test Equipment

The success or failure in troubleshooting a complex piece of equipment like the Model 195A depends not only on the skill of the technician, but also relies heavily on accurate, reliable test equipment. Table 7-11 lists the minimum equipment and specifications recommended for troubleshooting the Model 195A. Other equipment such as logic analyzers, capacitance meters, etc, could also be helpful in difficult situations.

7.8.2 Power-Up Self Diagnostics

An advanced feature of the Model 195A is its self diagnosing capabilities. Upon power-up, the following tests are automatically performed.

1. Display Test. All segments will light for 3.5 seconds as follows:

   -1.8.8.8.8.8.8

   During the display test the following test are performed in sequence:

   A. RAM test. If the RAM test fails, the following error message will be displayed:

   1AAAAA

   B. ROM Test. If the ROM test fails, the following message will be displayed:

   100000

   The Model 195A will lock up under these conditions. Since instrument operating requires that the software be in good working order, there is little point in attempting to troubleshoot elsewhere unless the ROMs are operating properly.

2. Non-volatile RAM Test. If the NVRAM test fails, the following message will be displayed:

   unCAL

   This is a succinct message indicating that the instrument is probably not properly calibrated since calibration constants are stored in the non-volatile RAM. The Model 195A will lock up at this point if the test fails, but operation may be restored for troubleshooting by pressing any front panel control button. Calibration constants will be at unity, frequency at 60Hz, the IEEE address at 60Hz, and Model 1950 option set to "no OP" status.

3. If the preceding tests pass, the instrument will then display the programmed line frequency and software level. For example:

   F60 E5

   This means that a programmed frequency of 60Hz with a software revision level of E5.

4. The IEEE primary address is then displayed, for example:

   IE 16

If all the test pass successfully, then it is reasonable to assume that the microcomputer and ROM and RAM are operating properly. The technician may then concentrate his efforts elsewhere in the instrument.

7.8.3 Self Diagnostic Program

Many of the power-up diagnostic tests may be performed by running front panel Program 8. Other aspects of Program 0 are designed to switch on various switching FETs or relays to allow signal tracing through the instrument.

To use the self diagnostic program, enter the following button sequence.

1. Press PRGM. The instrument will then prompt for a program number:

   Pro ?

Table 7-11. Recommended Troubleshooting Equipment

Equipment	Use
Five-function DMM with 0.05% basic DC accuracy, 10MΩ input impedance (Keithley Model 175 or equivalent).	Power supply and DC voltage checks; analog signal tracing continuity, static logic levels.
Dual-trace, triggered-sweep oscilloscope, DC to 50MHz bandwidth.	Digital and analog waveform checks.

2. Press 8. The instrument then runs the test then prompts for a test number, n, as follows:

tESt?

3. To enter one of the four FET switching phases, enter a number between 1 and 4. Table 7-12 lists the FET and relay switching sequence for the various range, function and n value combinations. To run one of the remaining tests, which are listed in Table 7-13, press the appropriate number between 5 and 7.

Table 7-12 shows which switching FETs and relays will be on and what the buffer gain will be for various tests on different ranges and functions (n = test number). This test procedure greatly simplifies troubleshooting. To troubleshoot using this test, proceed as follows:

1. Select the desired range and function.
2. Enter Program 8 as previously described.
3. Enter the desired test number, n, (1-4) listed in Table 7-12.
4. The instrument will remain in the selected configuration until another parameter is selected or until Program 8 is cancelled. (The bit pattern is continually shifted to test the opto-isolators and shift registers.)

Table 7-12. FET and Relay Switching Sequence For Various N Modes

Function And Range	Mode	Gain FET On	Input Buffer Gain	Multiplexer FET On	Ohms Range FETS On	Model 195A Relays Energized	Model 1950 FETS On	Model 1950 Relays Energized
1000VDC	N1	Q117	X1	Q111				
	N2	Q117	X1	Q114				
	N3	Q117	X1	Q103				
	N4	Q117	X1	Q114				
200VDC	N1	Q117	X1	Q113				
	N2	Q117	X1	Q114				
	N3	Q117	X1	Q103				
	N4	Q117	X1	Q114				
20VDC	N1	Q118	X10	Q113				
	N2	Q118	X10	Q114				
	N3	Q117	X1	Q103				
	N4	Q117	X1	Q114				
2VDC	N1	Q117	X1	Q109		RL1		
	N2	Q117	X1	Q114		RL1		
	N3	Q117	X1	Q103		RL1		
	N4	Q117	X1	Q114		RL1		
200mVDC	N1	Q118	X10	Q109		RL1		
	N2	Q118	X10	Q114		RL1		
	N3	Q117	X1	Q103		RL1		
	N4	Q117	X1	Q114		RL1		
20mVDC	N1	Q119	X100	Q109		RL1		
	N2	Q119	X100	Q114		RL1		
	N3	Q117	X1	Q103		RL1		
	N4	Q117	X1	Q114		RL1		
20MΩ	N1	Q117, Q118	X2	Q111	Q115	RL2		
	N2	Q117, Q118	X2	Q110	Q115	RL2		
	N3	Q117, Q118	X2	Q108	Q115	RL2		
	N4	Q117, Q118	X2	Q113	Q115	RL2		
2MΩ	N1	Q118	X10	Q111	Q115	RL2		
	N2	Q118	X10	Q110	Q115	RL2		
	N3	Q117	X1	Q108	Q115	RL2		
	N4	Q117	X1	Q113	Q115	RL2		
200kΩ	N1	Q117, Q118	X2	Q111	Q122	RL1, RL2		
	N2	Q117, Q118	X2	Q110	Q122	RL1, RL2		
	N3	Q117, Q118	X2	Q109	Q122	RL1, RL2		
	N4	Q117, Q118	X2	Q107	Q122	RL1, RL2		
20kΩ	N1	Q118	X10	Q111	Q122	RL1, RL2		
	N2	Q118	X10	Q110	Q122	RL1, RL2		
	N3	Q117	X1	Q109	Q122	RL1, RL2		
	N4	Q117	X1	Q107	Q122	RL1, RL2		
2kΩ	N1	Q117, Q118	X2	Q111	Q121	RL1, RL2		
	N2	Q117, Q118	X2	Q110	Q121	RL1, RL2		
	N3	Q117, Q118	X2	Q109	Q121	RL1, RL2		
	N4	Q117, Q118	X2	Q108	Q121	RL1, RL2		
200Ω	N1	Q118	X10	Q111	Q121	RL1, RL2		
	N2	Q118	X10	Q110	Q121	RL1, RL2		
	N3	Q117	X1	Q109	Q121	RL1, RL2		
	N4	Q117	X1	Q108	Q121	RL1, RL2		

Table 7-12. FET and Relay Switching Sequence For Various N Modes (Cont.)

Function And Range	Mode	Gain FET On	Input Buffer Gain	Multiplexer FET On	Ohms Range FETS On	Model 195A Relays Energized	Model 1950 FETS On	Model 1950 Relays Energized
20Ω	N1	Q119	X100	Q111	Q121	RL1, RL2		
	N2	Q119	X100	Q110	Q121	RL1, RL2		
	N3	Q117	X1	Q109	Q121	RL1, RL2		
	N4	Q117	X1	Q108	Q121	RL1, RL2		
700VAC	N1	Q117	X1	Q102			Q505	K501, K504 K506
	N2	Q117	X1	Q114			Q505	↓
	N3	Q117	X1	Q103			Q505	
	N4	Q117	X1	Q114			Q505	
200VAC	N1	Q117	X1	Q102			Q505	K501, K504 K505
	N2	Q117	X1	Q114			Q505	↓
	N3	Q117	X1	Q103			Q505	
	N4	Q117	X1	Q114			Q505	
20VAC	N1	Q117	X1	Q102			Q501, Q504 Q505	K501, K504 K505
	N2	Q117	X1	Q114			↓	↓
	N3	Q117	X1	Q103				
	N4	Q117	X1	Q114				
2VAC	N1	Q117	X1	Q102			Q505	K501, K504
	N2	Q117	X1	Q114			Q505	K501, K504
	N3	Q117	X1	Q103			Q505	K501, K504
	N4	Q117	X1	Q114			Q505	K501, K504
200mVAC	N1	Q117	X1	Q102			Q501, Q504 Q505	K501, K504
	N2	Q117	X1	Q114			↓	K501, K504
	N3	Q117	X1	Q103				K501, K504
	N4	Q117	X1	Q114				K501, K504
2A AC	N1	Q117	X1	Q102			Q501, Q504 Q505	K501
	N2	Q117	X1	Q114			↓	K501
	N3	Q117	X1	Q103				K501
	N4	Q117	X1	Q114				K501
200mA AC	N1	Q117	X1	Q102			Q501, Q504 Q505	K502
	N2	Q117	X1	Q114			↓	K502
	N3	Q117	X1	Q103				K502
	N4	Q117	X1	Q114				K502
20mA AC	N1	Q117	X1	Q102			Q501, Q504, Q505	K503
	N2	Q117	X1	Q114			↓	K503
	N3	Q117	X1	Q103				K503
	N4	Q117	X1	Q114				K503
2mA AC	N1	Q117	X1	Q102			Q501, Q503, Q504, Q505	
	N2	Q117	X1	Q114			↓	
	N3	Q117	X1	Q103				
	N4	Q117	X1	Q114				

Table 7-12. FET and Relay Switching Sequence For Various N Modes (Cont.)

Function And Range	Mode	Gain FET On	Input Buffer Gain	Multiplexer FET On	Ohms Range FETS On	Model 195A Relays Energized	Model 1950 FETS On	Model 1950 Relays Energized
200μA AC	N1	Q117	X1	Q102			Q501, Q502, Q504, Q505	NONE
	N2	Q117	X1	Q114				NONE
	N3	Q117	X1	Q103				NONE
	N4	Q117	X1	Q114				NONE
2A DC	N1	Q118	X10	Q102			Q506	K501
	N2	Q118	X10	Q114			Q506	K501
	N3	Q117	X1	Q103			Q506	K501
	N4	Q117	X1	Q114			Q506	K501
200mA DC	N1	Q118	X10	Q102			Q506	K502
	N2	Q118	X10	Q114			Q506	K502
	N3	Q117	X1	Q103			Q506	K502
	N4	Q117	X1	Q114			Q506	K502
20mA DC	N1	Q118	X10	Q102			Q503, Q506	NONE
	N2	Q118	X10	Q114			Q503, Q506	NONE
	N3	Q117	X1	Q103			Q503, Q506	NONE
	N4	Q117	X1	Q114			Q503, Q506	NONE
2mA DC	N1	Q118	X10	Q102			Q506	K504, K503
	N2	Q118	X10	Q114			Q506	K504, K503
	N3	Q117	X1	Q103			Q506	K504, K503
	N4	Q117	X1	Q114			Q506	K504, K503
200μA DC	N1	Q118	X10	Q102			Q502, Q506	K504
	N2	Q118	X10	Q114			Q502, Q506	K504
	N3	Q117	X1	Q103			Q502, Q506	K504
	N4	Q117	X1	Q114			Q502, Q506	K504
20μA DC	N1	Q119	X100	Q102			Q502, Q506	K504
	N2	Q119	X100	Q114			Q502, Q506	K504
	N3	Q117	X1	Q103			Q502, Q506	K504
	N4	Q117	X1	Q114			Q502, Q506	K505

Once the various circuit elements have been switched on, signal tracing is a fairly straight forward process. For example, if the instrument is on the 20VDC range, during the N1 phase, Q118 will be turned on, giving the buffer amplifier a gain of X10. At the same time, multiplexer FET Q113 is turned on. During the N2 phase, Q118 remains on, but the multiplexer FET that is turned on is Q114. During the N3 and N4 phases, the gain FET is Q117, giving the buffer amplifier a gain of X1, while Q103 and Q114 are multiplexer FETs that are turned on during the N3 and N4 phases respectively.

The remainder of the tests in Table 7-13 are pretty much self explanatory. If the ROM or RAM tests are successful, the PASS message will be displayed. If either of these tests fails, the associated error message will be displayed. In any case, instrument operation may be restored for troubleshooting by cancelling Program 8 with the PRGM button. Note that, if the RAM test fails, the routine repeatedly writes and reads from the defective memory location.

7.8.4 Power Supply Checks

Every techinician's motto should be: "Step 1, check the power supply." If the various supply voltages within the instrument are not within the required limits, troubleshooting the remaining circuitry can be very difficult.

Table 7-14 shows the various checks that can be made to the power supplies within the Model 195A. In addition to the normal voltage checks, it is also a good idea to check the various supplies with an oscilloscope to make sure no noise or ringing is present.

7.8.5 A/D Converter and Display

Make sure the A/D converter and display are operating properly before attempting to troubleshoot the signal conditioning circuits. Check these circuits using the information in Tables 7-15 and 7-16.

Table 7-13. Program 8 Tests

Test Number (n)	Display Message	Comments
1-4		FET Switching See Table 7-12.
5-7	PASS	Passed ROM, RAM, or A/D Test
7	-1.8.8.8.8 8+8	Display Test
5	roE	Failed ROM Test
6	rAE	Failed RAM Test

Table 7-14. Power Supply Checks

Step	Item/Component	Required Condition	Remarks
1	S102 Line Switch	Set to 115 or 230V as required.	See paragraph 7.2.
2	F101 Line Fuse	Continuity	Remove fuse to check.
3	J1003 Line Power	Plugged into live receptacle; power on.	
4	+5V Analog	+5V ±5%	+5V pad next to shield.
5	VR102 Input	8V minimum	Output of CR107
6	+15V Supply	+15V ±10%	+15V pad next to shield.
7	VR103 Input	+18V minimum	Positive output of CR108.
8	−15V Supply	−15V ±10%	−15V pad next to shield.
9	VR105 Input	−18V minimum	Negative output of CR108
10	+5V Digital	+5V ±5%	Measure between +5V Digital and Digital Common pads next to C14.
11	VR101 Input	+8V minimum	Reference to Digital Common.

Table 7-15. A/D Converter Checks

Step	Item/Component	Required Condition	Remarks
1		Turn on power, select 1000VDC range.	Some tests here could fail due to digital problems.
2	Display	000.0 ±1 digit	
3	U125, pin 1	0 to +4V square wave at 614.4kHz.	614.4kHz clock
4	U121, pin 2	0 to +4V square wave at 1.2288mHz.	1.2288MHz clock
5	TP2	0.5V to +4V 0.8μs sawtooth waveform	Test point.
6	TP1	Integrator ramp.	Test point
7	TP3	Variable pulse train.	Data out.
8	U121, pin 6	Variable pulse train.	Analog control.
9	U129, pin 5	0 to 4V pulse 5ms (approx.) duration.	A/D control.
10	U129, pin 6	0 to 4V pulse 1ms (approx) duration	A/D control.
11	U129, pin 7	0 to 4V pulse 15ms duration.	A/D control
12	U135 pins 10, 11, 12, 13	Enter Program 8, n=1	Pin 11 HI; 10, 12, 13 LO.
13	U135 pins 10, 11, 12, 13	Program 8, n=2	Pin 10 HI; 11, 12, 13 LO.
14	U135 pins 10, 11, 12, 13	Program 8, n=3	Pins 10, 11, LO; 12, 13 HI.

Table 7-16. Display Board Checks

Step	Item/Component	Required Condition	Remarks
1		Turn on power. Select 1000VDC range.	Initial power-up test checks all display segments. All voltages referenced to digital common.
2	U203, pins 2, 9, 14	+5V ±5%	5V digital.
3	U201, U202 pin 11	+5V ±5%	5V digital.
4	U203, pin 1	+4V 2ms pulse every 17ms.	Data in to shift register.
5	U203 pin 8	0V (Negative-going) 20μs pulse every 2ms.	Shift register clock.
6	U203, pins 3, 4, 5, 6, 10, 11, 12, 13	0 to +4V 2ms pulse every 17ms	Shift register outputs.
7	P1008, pin 13	Depress and hold RECALL/ENT button; 0V indication.	If different, S213 is defective.
8	P1008, pin 12	Depress and hold RESOLN, UP, OHMS, or DOWN buttons. Observe 4V to 0V 2ms pulse every 17ms.	Pulse present when button held in. Not present when button released.
9	P1008, pin 11	Depress and hold TRIG, AMPS, VOLTS or AUTO buttons. Observe 4V to 0V 2ms pulse every 17ms.	Pulse present when button held in. Not present when button released.
10	P1008, pin 12	Depress and hold PRGM, ZERO, FILTER, or AC buttons. Observe 4V to 0V 2ms pulse every 17ms.	Pulse present when button held in. Not when button released.

7.8.6 Input Attenuator and Ohms Source Checks

Problems in these circuits could affect DC and resistance ranges. Tables 7-17 and 7-18 list checks to be made on these circuits.

7.8.7 Input Multiplexer and Buffer Amplifier

Checks on these circuits may be made using the information in Table 7-12, which lists the FET and relay switching sequence for the various ranges and functions.

7.8.8 Digital Circuitry

Problems with the digital circuitry could cause erratic operation. Check the various components associated with the digital circuitry, including the IEEE interface, using the information in Table 7-19.

7.8.9 Model 1950 AC/Amps Option

Problems with the Model 1950 option could affect the AC and current ranges. Also, since input switching is performed within the Model 1950, relay problems could affect the DC voltage ranges as well. Table 7-20 lists the various aspects of the Model 1950 operation to be checked.

7.8.10 Buffer Amplifier Gain Checks

Problems with the buffer amplifier could affect every range and function. Depending on the problem, one or more buffer amplifier gain factors may be incorrect. To check the buffer amplifier at all four gain values (X1, X2, X10 and X100), proceed as follows:

1. Apply the calibrated input signal listed in Table 7-21.
2. Enter front panel Program 8.
3. Enter the correct test number, n, listed in the table.
4. Measure the buffer amplifier output voltage at TP5 (pin 6 of U137).
5. Compare the required value with the listed value in the table.
6. Repeat the procedure for each of the listed gain values.

NOTE

All voltages in the troubleshooting tables are referenced to analog common, which is connected to the VOLTS OHMS LO terminal, unless otherwise noted.

Table 7-17. DC Attenuator Checks

Step	Item/Component	Required Condition	Remarks
1		Turn on power, select 1000VDC range.	These checks assume 20mV, 200mV, and 2V ranges are functioning properly.
2	External Voltage	+990.00VDC	Instrument calibration value.
3	Display	990.00 ±10 digits	If different, check K101, R144.
4		Set to 200VDC range.	
5	External Voltage	+190.00VDC	Instrument calibration value.
6	Display	190.00 ±10 digits	If different, check K102, R144.
7		Set to 20VDC range.	
8	External Voltage	+19.000VDC	Instrument calibration value.
9	Display	19.000 ±10 digits	If different, check K102, R144.

Table 7-18. Ohms and −2V Reference Source Checks

Step	Item/Component	Required Condition	Remarks
1		Select 20Ω range and short VOLTS OHMS terminals with 18 guage or larger copper wire.	Do not perform these test unless A/D converter and attenuator check out.
2	Display	Less than 00.010	Two wire offset, including thermals.
3	U143, pin 5	−2V ±10%	−2V reference. If different, go to step 6.
4	U143, pin 15	−15V ±10%	−15V supply to ohms source.
5	CR109 anode	−2V ±10%	Ω source.
6	R128 pin 2 or 3	−2V ±10%	−2V reference.
7	VR105 anode	6.35V ±5%	
8	U143, pin 4	−15V ±10%	
9	R128, pins 1 & 2	10.875kΩ ±0.1%	Reference source divider.
10	R128, pins 3 & 4	5kΩ ±0.1%	Reference source divider.
11	U143, pin 2	6.35V ±5%	

WARNING
Some procedures in the following tables require the use of potentially dangerous high voltages. Use normal precautions to avoid contact with live circuits which could cause personal injury or death. The mother board shield it at VOLTS OHMS LO potential. An input voltage floating high enough will create a shock hazard between the shield and chassis ground.

Table 7-19. Digital Circuitry Checks

Step	Item/Component	Required Condition	Remarks
1		Power on, 1000VDC range.	Voltages referenced to digital common.
2	U117, pins 35, 8	+5V ±5%	+5V digital supply.
3	U117 pin 2	+4V ±20%	MPU $\overline{\text{HALT}}$ line.
4	U117 pin 6	+4V ±20%	MPU $\overline{\text{NMI}}$ line.
5	U117 pin 40	Turn off instrument then back on.	$\overline{\text{RESET}}$ line pin 40 stays LO for about 1 second after power on then goes HI.
6	U117 pin 37	1MHz Square Wave	Also check for system clock on U108, U110, U111, U112 and U118.
7	U108 pin 16	20μs variable pulse.	Serial data in.
8	U108 pin 19	0.5ms variable pulse train.	Serial analog control.
9	U108 pin 21	100μs negative going pulses, variable intervals.	$\overline{\text{IRQ}}$ line.
10	U108 pins 2-9	0 to +4V 2ms pulses.	Display and NVRAM data.

Table 7-20. Model 1950 Option Checks

Step	Item/Component	Required Condition	Remarks
1	Model 1950 Option	Remove screws securing option. Remove option and analog shield.	Do not disconnect option or remove option shield. These tests assume Model 195A is operating properly.
2		Power on, select 2A DC range.	
3	External DC Current	1.9000A	Calibration current.
4	Program 8	Enter program, n=1	Program 8 test hold Q102 on.
5	TP5 on Model 195A (Buffer Output)	+1.9VDC	Referenced to analog common.
6	External DC Current	190.00mA ±0.1%	Calibration current.
7	Range	Select 200mA DC range.	
8	External DC Current	+190.00mA	Calibration current.
9	Program 8	n=1	
10	TP5	+1.9VDC	Referenced to analog common.
11	External DC Current	+19.00mA	Calibration current.
12	Range	Select 20mA DC range.	
13	Program 8	n=1	
14	TP5	+1.9VDC	Referenced to analog common.
15	Range	Select 2mA DC range.	
16	External DC Current	1.9000mA DC	Calibration current.
17	Program 8	n=1	
18	TP5	+1.9VDC	Referenced to analog common.
19	Range	Select 200μA DC range.	
20	External DC Current	190.00μA DC	Calibration current.
21	Program 8	n=1	
22	TP5	+1.9VDC	Referenced to analog common.

Table 7-20. Model 1950 Option Checks (Cont.)

Step	Item/Component	Required Condition	Remarks
23	Range	20μA DC	
24	External DC Current	+19.000μA	Calibration current.
25	Program 8	n=1	
26	TP5	+1.9VDC	Referenced to analog common.
27	Function and range.	Select 700VAC range.	
28	External AC Voltage	700.00VAC RMS 1kHz	Calibration voltage.
29	Program 8	n=1	
30	TP5	+1.4DC	Referenced to analog common.
31	External AC Voltage	190.00VAC RMS 1kHz	Calibration voltage.
32	AC Voltage Range	200VAC	
33	Program 8	n=1	
34	TP5	+1.9VDC	Referenced to analog common.
35	External AC Voltage	19.000VAC RMS 1kHz	Calibration voltage.
36	Range	20VAC	
37	Program 8	n=1	
38	TP5	+1.9VDC	Referenced to analog common.
39	External AC Voltage	1.9000VAC RMS 1kHz	Calibration voltage.
40	Range	2VAC	
41	Program 8	n=1	
42	TP5	+1.9VDC	Referenced to analog common.
43	External AC Voltage	190mVAC RMS 1kHz	Calibration voltage.
44	Range	200mVAC	
45	Program 8	n=1	
46	TP5	+1.9VDC	Referenced to analog common.
47		Replace analog shield. Remove Model 1950 shield.	Place option on top of analog shield.
48	Range	200mADC	
49	External Current	190.00mADC	Calibration current.
50	TP1 (Model 1950)	0.19VDC	Test point.
51	Range	2VAC	
52	External Voltage	1.9VAC RMS 1kHz	Calibration voltage.
53	TP2	1.9VAC RMS	Test point.
54	TP3	+1.9VDC	Test point.

Table 7-21. Buffer Amplifier Gain Checks

Step	Function and Range	Applied Calibration Value (VOLTS OHMS Terminals)	Program 8 Test N Mode	Gain Factor	Measurement
1	200VDC	+190.00V	N1	X1	+1.90VDC
2	200kΩ	none (short terminals)	N4	X2	−4.0VDC
3	20VDC	+19.00V	N1	X10	+1.90VDC
4	20mVDC	+19.00mV	N1	X100	+1.90VDC

SECTION 8
REPLACEABLE PARTS

8.1 INTRODUCTION

This section contains replacement parts information, schematic diagrams, and component location drawings for the Model 195A. Also included is an exploded view of the instrument showing its general mechanical layout (see Figure 8-1).

8.2 PARTS LIST

Parts lists for the Model 195A mother board, display board and the Model 1950 option can be found listed in Table 8-2 through 8-5. Parts listed in each table are listed alphabetically in order of their circuit designation.

8.3 ORDERING INFORMATION

Keithley Instruments maintains a complete inventory of all normal replacement parts. To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory. When ordering parts, include the following information:

1. Instrument Model Number
2 . Instrument Serial Number
3. Part Description
4. Circuit designation, including schematic and component layout numbers (if applicable).
5. Keithley Part Number

8.4 FACTORY SERVICE

If the instrument is to be returned to the factory for service, carefully pack the instrument (see paragraph 1.9) and include the following:

1. Complete the service form which follows this section and return it with the instrument.
2. Advise as to the warranty status of the instrument.
3. Write ATTENTION REPAIR DEPARTMENT on the shipping label.

8.5 SCHEMATIC DIAGRAMS AND COMPONENT LOCATION DRAWINGS

Schematic diagrams are component location drawings can be found immediately following the parts list. Table 8-1 summarizes Model 195A drawings included in this section.

Table 8-1. Index of Model 195A Schematic and Component Layouts

Figure	Title	Dwg. No.
8-2	NVRAM Modification Board Component Layout	195-160
8-3	1950 AC Option Component Layout	1950-150
8-4	Mother Board Component Layout	195-100
8-5	Display Board Component Layout	195-110
8-6	NVRAM Modification Board Schematic Diagram	195-166
8-7	Mother Board Schematic Diagram Diagram	195-106
8-8	Display Board Schematic Diagram	195-116
8-9	1950 AC Option Schematic	1950-156

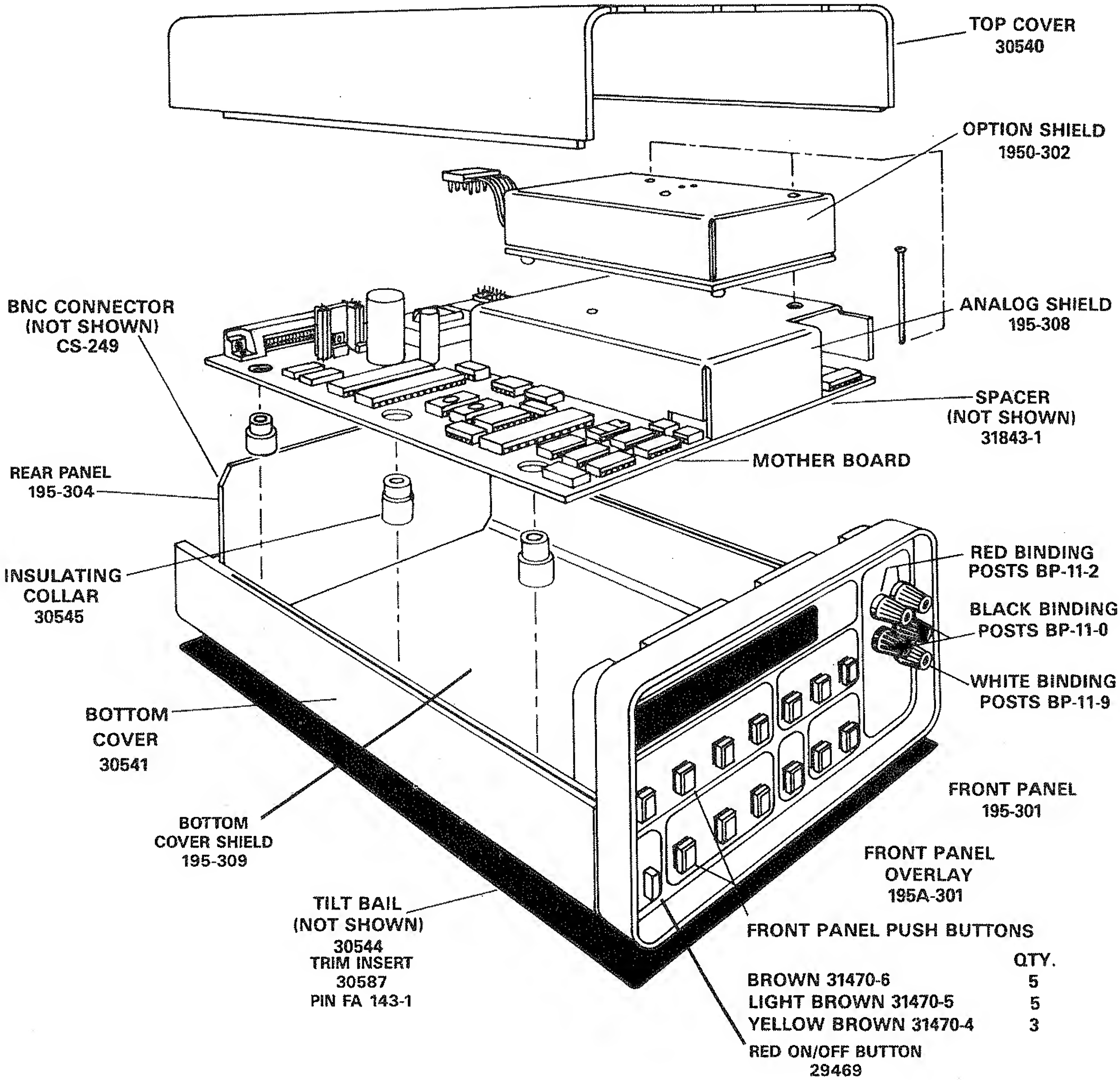


Figure 8-1. Model 195A Exploded View

Table 8-2. Mother Board 195-103, Parts List

Circuit Desig.	Description	Location Sch	Location Pcb	Keithley Part No.
C101	Capacitor, .1μF, 50V, Ceramic Film	2/F1	B3	C-237-.1
C102	Capacitor, .1μF, 50V, Ceramic Film	4/E2	B3	C-237-.1
C103	Capacitor, .1μF, 50V, Ceramic Film	4/D2	C2	C-237-.1
C104	Capacitor, .1μF, 50V, Ceramic Film	4/C2	C2	C-237-.1
C105	Capacitor, .1μF, 50V, Ceramic Film	4/B2	D2	C-237-.1
C106	Capacitor, 22pF, 1000V, Ceramic Disk	4/A3	D3	C-64-22p
C107	Capacitor, 1μF, 50V, Ceramic Film	4/B6	D3	C-237-1
C108	Capacitor, 22pF, 100V, Ceramic Disk	4/A3	E3	C-64-22p
C109	Capacitor, .1μF, 50V, Ceramic Film	4/A5	E3	C-237-.1
C110	Capacitor, .1μF, 50V, Ceramic Film	4/E3	E3	C-237-.1
C111	Capacitor, .1μF, 50V, Ceramic Film	4/F3	E2	C-237-.1
C112	Capacitor, .1μF, 50V, Ceramic Film	4/F6	F2	C-237-.1
C113	Capacitor, 10μF, 25V, Aluminum Electrolytic	1/F3	F2	C-314-10
C114	Capacitor, 10000μF, Aluminum Electrolytic	1/D3	E3	C-342-10000
C115	Capacitor, .1μF, 50V, Ceramic Film	2/E2	A3	C-237-.1
C116	Capacitor, 6800pF, 10%, 500V, Ceramic Disk	2/D5	A3	C-22-6800p
C117	Capacitor, 150pF, 10%, 500V, Ceramic Disk	2/B6	A3	C-22-150p
C118	Capacitor, 33pF, 500V, Ceramic Disk	2/A6	A4	C-22-33p
C119	Capacitor, .1μF, 50V, Ceramic Film	2/C2	D4	C-237-.1
C120	Capacitor, 10μF, 25V, Aluminum Electrolytic	1/F4	D3	C-314-10
C121	Capacitor, 2200μF, 25V, Aluminum Electrolytic	1/D4	E3	C-314-2200
C122	Capacitor, 10μF, 25V, Aluminum Electrolytic	1/F4	D3	C-314-10
C123	Capacitor, 620μF, 35V, Aluminum Electrolytic	1/D4	E3	C-309-680
C124	Capacitor, 33pF, 500V, Ceramic Disk	3/E3	C4	C-22-33p
C125	Capacitor, 3600pF, 500V, Polystyrene	2/B2	D4	C-138-3600p
C126	Capacitor, 10μF, 25V, Aluminum Electrolytic	1/F2	D4	C-314-10
C127	Capacitor, 620μF, 35V, Aluminum Electrolytic	1/D5	E4	C-309-680
C128	Capacitor, .1μF, 50V, Ceramic Film	2/F3	A5	C-237-.1
C129	Capacitor, 330pF, 500V, Polystyrene	3/C3	C5	C-138-330p
C130	Capacitor, 1500pF, 500V, Polystyrene	3/F4	D4	C-138-1500p
C131	Capacitor, .1μF, 50V, Ceramic Film	2/H4	A5	C-237-.1
C132	Capacitor, 1000pF, 1000V, Ceramic Disk	3/D1	B5	C-64-150p
C133	Capacitor, 1000pF, 500V, Polystyrene	3/C5	C5	C-138-1000p
C134	Capacitor, 3600pF, 500V, Polystyrene	—	C5	C-138-3600pF
C136	Capacitor, .01μF, 500V, Ceramic Disc	4/B6	D3	C-22-.01
C137	Capacitor, .01μF, 50V, Ceramic Film	4/A6	D3	C-237-.1
CR101	Silicon Diode, 1N4148	4/G2	C3	RF-28
CR102	Silicon Diode, 1N4148	4/G2	C3	RF-28
CR103	Silicon Diode, 1N4148	4/G2	C3	RF-28
CR104	Silicon Diode, 1N4148	4/G2	C3	RF-28
CR105	Silicon Diode, 1N4148	4/B6	D3	RF-28
CR106	Rectifier Bridge, 5A, 50 PIV	1/D3	F3	RF-48
CR107	Rectifier Bridge, 5A, 50 PIV	1/D4	E3	RF-48
CR108	Rectifier, Silicon, 1.5A, 400PIV	1/D5	E4	RF-46
CR109	Rectifier, Silicon, 1N4006, 1A, 800PIV	3/D1	B5	RF-38
CR110	Silicon Diode, 1N4148	—	D3	RF-28
F101	Fuse, 3/16A, 115V, American	1/B4	G3	FU-29
F101	Fuse, 1/10A, 230V, American	1/B4	G3	FU-40
F101	Fuse, 1/10A, 230V, European	1/B4	G3	FU-31
F101	Fuse, 3/16A, 115V, European	1/B4	G3	FU-32
F102	Fuse, 2A, 250V, American	3/B6	G5	FU-13
F102	Fuse, 2A, 250V, European	3/B6	G5	FU-48
J1001	Socket 16 pin	4/D1	A2	SO-65
J1002	Socket 24 pin IEEE	4/G5	G2	CS-443

Table 8-2. Mother Board 195-103, Parts List (Cont.)

Circuit Desig.	Description	Location Sch	Location Pcb	Keithley Part No.
J1003	Socket Line Cord	1/B5	G4	CS-388
J1004	Socket 14 pin	2/H4	E4	SO-70
J1005	Pin, Contact	—	B3	24249
J1006	Pin, Contact	—	C3	24249
J1007	Pin, Contact	—	E3	24249
J1008	Pin, Contact	—	F5	24249
J1009	Pin, Contact	3/B6	E5	24249
J1010	Pin, Contact	3/B6	F5	24249
J1011	Pin, Contact	3/B4	D5	24249
J1012	Pin, Contact,	3/B4	E5	24249
K101	Relay	3/B4	D5	RL-72
K102	Relay	3/B4	D5	RL-72
Q101	Transistor, Silicon, NPN, 2N3904	2/E2	B4	TG-47
Q102	JFET, N-Channel	2/E2	B4	193-603
Q103	JFET, N-Channel	3/D3	B4	193-603
Q104	JFET, N-Channel	3/D6	C4	TG-139
Q105	Transistor, Silicon, PNP, 2N3906	3/E4	C4	TG-84
Q106	Transistor, Silicon, PNP, 2N3906	2/C3	D3	TG-84
Q107	JFET, N-Channel	2/C3	D3	TG-139
Q108	JFET, N-Channel	3/D2	B4	TG-139
Q109	JFET, N-Channel	3/D3	B4	193-603
Q110	JFET, N-Channel	3/D4	C4	193-603
Q111	JFET, N-Channel	3/D6	C4	193-603
Q112	JFET, N-Channel	3/D5	C4	193-603
Q113	JFET, N-Channel	3/E4	C4	193-603
Q114	JFET, N-Channel	3/D5	C4	193-603
Q115	FET, N-Channel, Selected	3/D4	C4	31841
Q116	FET, N-Channel	3/C4	C4	TG-128
Q117	FET, N-Channel	2/B2	C5	TG-128
Q118	FET, N-Channel	3/F3	C4	TG-128
Q119	FET, N-Channel	3/F4	D4	TG-128
Q120	Transistor, Silicon, NPN, Planar, 2N3565	3/F4	D4	TG-139
Q121	FET, N-Channel, Selected	3/E1	B5	31841
Q122	FET, N-Channel, Selected	3/C2	C5	31841
Q123	Transistor, Silicon, NPN, TIP49	3/C2	C5	TG-137
Q124	JFET, N-Channel	3/D2	C5	TG-139
R101	Resistor, Thick Film Network	4/B1	B2	TF-100
R102	Resistor, 220Ω, 5%, 1/4W, Composition	2/F2	B3	R-76-220
R103	Resistor, 10kΩ, 5%, 1/4W, Composition	4/G2	B3	R-76-10k
R104	Resistor, 330Ω, 5%, 1/4W, Composition	4/F3	B3	R-76-330
R105	Resistor, 100Ω, 5%, 1/4W, Composition	4/G2	C3	R-76-100
R106	Resistor, 100Ω, 5%, 1/4W, Composition	4/G2	C3	R-76-100
R107	Resistor, Thick Film Network	4/A6	D2	TF-101
R108	Resistor, 1MΩ, 5%, 1/4W, Composition	4/B6	D3	R-76-1M
R109	Resistor, 249Ω, 0.5%, 1/8W, Metal Film	1/E3	F2	R-246-249
R110	Resistor, 750Ω, 0.5%, 1/8W, Metal Film	1/E3	F2	R-246-750
R111	Resistor, 220Ω, 5%, 1/4W, Composition	2/E2	B3	R-76-220
R112	Resistor, 330Ω, 5%, 1/4W, Composition	2/E2	B3	R-76-330
R113	Resistor,15MΩ, 5%, 1/4W, Composition	2/A5	B3	R-76-15M
R114	Resistor, 2.2kΩ, 5%, 1/4W, Composition	2/A5	B3	R-76-2.2k
R115	Resistor, 10kΩ, 5%, 1/4W, Composition	2/D3	D3	R-76-10k

Table 8-2. Mother Board 195-103, Parts List (Cont.)

Circuit Desig.	Description	Location Sch	Location Pcb	Keithley Part No.
R116	Resistor, Thick Film Network	2/SEV	B4	TF-108
R117	Not Used			
R118	Resistor,910kΩ, 5%, 1/4W, Composition	3/C2	B4	R-282-910k
R119	Resistor, 910kΩ, 5%, 1/4W, Composition	3/D3	B4	R-282-910k
R120	Resistor, Thick Film Network	3/D4	C4	TF-146
R121	Resistor, 100kΩ, 5%, 1/4W, Composition	3/E3	C4	R-76-100k
R122	Resistor, 1kΩ, 5%, 1/4W, Composition	3/E3	C4	R-76-1k
R123	Resistor, 11kΩ, 1%, 1/8W, Composition	3/E3	C4	R-88-11k
R124	Resistor, 1MΩ, 1%, 1/8W	2/B2	D3	R-88-1M
R125	Resistor, 6.34kΩ, 1%, 1/8W	2/B3	D4	R-88-6.34k
R126	Resistor, 1MΩ, 5%, 1/4W, Composition	2/SEV	B4	R-76-1M
R127	Resistor, Thick Film Network	2/SEV	B4	TF-108
R128	Resistor, Thick Film Network	3/E5	B4	TF-150
R129	Resistor, 910kΩ, 5%, 1/4W, Composition	3/E5	B4	R-282-910k
R130	Resistor, 910kΩ, 5%, 1/4W, Composition	3/C6	B4	R-282-910k
R131	Resistor, 910kΩ, 5%, 1/4W, Composition	3/C3	B4	R-282-910k
R132	Resistor, 220kΩ, 10%, 1/2W, Composition	3/C4	C5	R-1-220k
R133	Resistor, 860kΩ, 1%, 1/8W, Composition	3/D5	C5	R-88-806k
R134	Resistor, 909kΩ, 1%, 1/8W, Composition	3/D4	C5	R-88-909k
R135	Resistor, 910kΩ, 5%, 1/4W, Composition	3/C5	C5	R-2-910k
R136	Resistor, Thick Film	3/F4	D5	TF-149
R137	Resistor, Thick Film	2/C2	D4	TF-85
R138	Resistor, 7.5kΩ, 5%, 1/4W, Composition	3/F5	B5	R-76-7.5k
R139	Resistor, 6.19kΩ, 1%, 1/8W, Composition	3/E5	B5	R-88-6.19k
R140	Resistor, 1.54kΩ, 1%, 1/8W, Composition	3/E5	B5	R-88-1.54k
R141	Resistor, 10.7kΩ, 1%, 1/8W, Composition	3/E5	B5	R-88-10.7k
R142	Resistor, 7.5kΩ, 1%, 1/8W, Composition	2/A3	C5	R-88-7.5k
R143	Resistor, 12.7kΩ, 1%, 1/8W, Composition	2/A3	C5	R-88-12.7k
R144	Resistor, Thick Film Network	3/C5	C5	TF-148
R145	Resistor, 10kΩ, 5%, 1/4W, Composition	3/D6	B5	R-76-10k
R146	Resistor, 10kΩ, 5%, 1/4W, Composition	3/D6	B5	R-76-10k
R147	Resistor, 3.3kΩ, 5%, 1/4W, Composition	3/D1	B5	R-76-3.3k
R148	Resistor, 220kΩ, 10%, 1/2W, Composition	3/D1	B5	R-1-220k
R149	Resistor, 1MΩ, 5%, 1/4W, Composition	3/C2	B5	R-76-1M
R150	Resistor, 1MΩ, 5%, 1/4W, Composition	3/C1	C5	R-76-1M
R151	Resistor, 1MΩ, 5%, 1/4W, Composition	3/C2	C5	R-76-1M
R152	Resistor, 1MΩ, 5%, 1/4W, Composition	3/C2	C5	R-76-1M
R153	Resistor, 100kΩ, 10%, 1W, Composition	3/D1	C5	R-2-100k
R154	Resistor, 10kΩ, 5%, 1/4W, Composition	3/D1	C5	R-76-10k
R155	Resistor, 680kΩ, 10%, 2W, Composition	3/C4	C5	R-3-680k
R156	Resistor, 1.000kΩ, 0.1%, 1/4W, Metal Film	3/C3	C5	R-264-1.000k
R157	Resistor, 100.0kΩ, 0.1%, 1/10W, Metal Film	3/C2	C5	R-263-100.0k
R158	Resistor, 100kΩ, 10%, 1W, Composition	3/A2	—	R-2-100k
R159	Resistor, 100kΩ, 10%, 1W, Composition	3/A3	—	R-2-100k
R160	Resistor, 100kΩ, 10%, 1W, Composition	3/A4	—	R-2-100k
R161	Resistor, 100kΩ, 10%, 1W, Composition	3/A5	—	R-2-100k
R162	Resistor, 61.9kΩ, 1%, 1/8W, Composition	B6	D3	R-88-61.9k
R163	Resistor, 1MΩ, 1%, 1/8W, Composition	B6	D2	R-88-1M
R164	Resistor, 20kΩ, 1%, 1/8W, Composition	B6	D2	R-88-20k
S101	Switch, Line	1/B4	B1	SW-466
S102	Switch, DPDT	1/B3	F3	SW-425
S103	Switch, Input	3/B4	F3	SW-443
T101	Transformer, Power (105-125V, 210-250V)	1/C3	F4	TR-194
T101	Transformer, Power (90-110V, 195-235V)	1/C3	F4	TR-196
U101	IC, Hex 3-state buffer, MC14503BCP	4/C1	B2	IC-250
U102	IC, Hex 3-state buffer, MC14503BCP	4/A1	B2	IC-250

Table 8-2. Mother Board 195-103, Parts List (Cont.)

Circuit Desig.	Description	Location Sch	Location Pcb	Keithley Part No.
U103	IC, Quad 2-Input NOR gate, 74LS02	4/G1	A2	IC-179
U104	IC, Opto coupler, 6N137	2/F2	A3	IC-292
U105	IC, Opto coupler, 6N137	2/F1	B3	IC-292
U106	IC, Dual D-type Flip-Flop, 74LS74	4/G3	B2	IC-144
U107	Not Used			
U108	IC, VIA, 6522	4/E2	B2	LSI-28
U109	IC, Decoder, 74LS139	4/B4	C2	IC-190
U110	IC, RAM, 4016	4/D3	C2	LSI-51
U111	Not Used			
U112	IC, PROM, 2764	4/B3	D2	195T-800-**
U113	IC, Hex Inverter 74LS04	4/SEV	C3	IC-186
U114	IC, Quad 2-input NAND Gate, 74LS00	4/SEV	C3	IC-163
U115	IC, 14-Stage Binary Counter, 4020	4/F1	D3	IC-280
U116	IC, 555 Timer	4/B6	D2	IC-71
U117	IC, Microprocessor, MC6808	4/A4	D2	LSI-27
U118	IC, GPIB Adapter TMS9914	4/E4	E2	LSI-49
U119	IC, Bus Transceiver, SN75160A	4/F4	E2	IC-298
U120	IC, Bus Transceiver, SN75161A	4/F5	F2	IC-299
U121	IC, Hex Inverter, 4049	2/SEV	B3	IC-106
U122	IC, 14-Stage Binary Counter, 4063	2/B5	B3	IC-197
U123	IC, Quad 2-Input AND Gate, CD4081BE	2/SEV	B3	IC-138
U124	IC, 4520	2/F5	C3	IC-324
U125	IC, Dual D-type Flip-Flop, 4013	2/B4	C3	IC-103
U126	IC, Quad 2-Input NOR Gate, 74LS02	2/SEV	C3	IC-179
U127	IC, Dual D-type Flip-Flop, 74S74N	2/C2	D3	IC-216
U128	IC, selected CA3086	2/B1	D3	29198
U129	IC, 8-bit Shift Register, MC14094BCP	2/F3	A4	IC-251
U130	IC, Quad Comparator, LM339	2/G5	B4	IC-219
U131	IC, Selected OP Amp	2/E3	C4	30167
U132	IC, Selected CA3086	2/B3	D4	29198
U133	IC, Voltage Comparator, LM311N	2/C2	D4	IC-173
U134	IC, JFET OP Amp, LF351N	2/B3	D4	IC-176
U135	IC, BCD-Decimal Decoder, CD4028AE	2/F5	A4	IC-135
U136	IC, Quad Comparator, LM339	2/SEV	B4	IC-219
U137	IC, OP Amp, 741	3/F3	C4	IC-42
U138	IC, JFET OP Amp, LF353N	3/F5	C5	IC-246
U139	IC, Darlington Array, ULN2003A	3/G3	C5	IC-206
U140	IC, 8-stage Shift Register, MC14094BCP	2/H5	E4	IC-251
U141	IC, Quad Comparator, LM-339	2/SEV	A5	IC-219
U142	IC, Quad Comparator, LM-339	2/SEV	B5	IC-219
U143	IC, JFET OP Amp, LF353	2/E5	B5	IC-246
VR101	IC, OP Amp, ICL7650	1/E2	F2	32469-3
VR102	IC, Regulator, +5V 1A, 7805	1/E4	E3	32469-4
VR103	IC, Regulator, +15V, 500mA, 78M15	1/E5	E4	IC-194
VR104	IC, Regulator, -15V, 500mA, 79M15	1/E5	E4	IC-195
VR105	Diode, Zener, 6.35V, 400mW	3/E6	B5	DZ-58
W101	Circuit Jumper		D3	J-15
W102	Circuit Jumper	3/B6	F5	J-15
W103	Circuit Jumper	3/B4	E5	J-15
W104	Circuit Jumper		B5	J-15
W106	Calibration Jumper		B4	J-3
W107	Calibration Jumper		A2	CS-447
W108	Calibration Jumper		A2	CS-447
Y101	4.0 MHz Crystal	4/A3	D3	CR-10
Y102	1.2288MHz Crystal	2/A5	B3	CR-19

** Order same software as presently installed. For example if E5 is displayed on power-up, order 195T-800-E5 for U111.

Table 8-3. NVRAM Board Parts List

Circuit Desig.	Description	Location Sch	Location Pcb	Keithley Part No.
C138	Capacitor, 0.1µF, 20%, 50V	D1	C1	C-237-.1
P1013	Connector, male, 9 pin (2 required)	E3	D2	CS-339-9
R165	Resistor, 10kΩ, 5%, 1/4W, Composition	D1	D1	R-71-10k
R166	Resistor, 61.9kΩ, 1%, 1/8W, Composition	C1	D1	R-88-61.9k
R167	Resistor, 267kΩ, 1%, 1/8W, Composition	C1	D1	R-88-1M
R168	Resistor, 20kΩ, 1%, 1/8W, Composition	C1	D1	R-88-20k
U145	IC, NVRAM	B3	C2	LSI-50
U146	IC, ICL8111L	C1	C1	IC-177

Table 8-4. Display Board 195-113, Parts List

Circuit Desig.	Description	Location Sch	Location Pcb	Keithley Part No.
C201	Capacitor, 10μF, 20V, Tantalum	D5	D4	C-179-10
DS201	Digital Display, ± 1	B2	A2	DD-32
DS202	Digital Display, "8"	C2	A2	DD-20
DS203	Digital Display, "8"	C2	B2	DD-20
DS204	Digital Display, "8"	D2	B2	DD-20
DS205	Digital Display, "8"	D2	C2	DD-20
DS206	Digital Display, "8"	E2	C2	DD-20
DS207	Digital Display, ± 1	E2	C2	DD-32
DS208	Digital Display, "8"	F2	D2	DD-20
DS209	LED, Red	G2	D2	PL-67
DS210	LED, Red	G2	D2	PL-67
DS211	LED, Red	H2	A3	PL-67
DS212	LED, Red	H3	B3	PL-67
DS213	LED, Red	H3	B3	PL-67
DS214	LED, Red	G3	C3	PL-67
DS215	LED, Red	G3	C3	PL-67
DS216	LED, Red	G3	B4	PL-67
DS217	LED, Red	G3	B4	PL-67
DS218	LED, Red	F3	C4	PL-67
DS219	LED, Red	F3	C4	PL-67
DS220	LED, Red	F3	D4	PL-67
P1001	Cable Assembly		A3	CA-15-2
Q201	Transistor, Silicon PNP	G4	D2	TG-90
Q202	Transistor, Silicon PNP	G4	E2	TG-90
Q203	Transistor, Silicon PNP	H4	D2	TG-90
Q204	Transistor, Silicon PNP	H4	E2	TG-90
Q205	Transistor, Silicon PNP	G4	D3	TG-90
Q206	Transistor, Silicon PNP	F4	E3	TG-90
Q207	Transisotr, Silicon PNP	F4	D3	TG-90
Q208	Transistor, Silicon PNP	G4	E3	TG-90
R201	Resistor, Thick Film Network	G5	A3	TF-77
R202	Resistor, Thick Film Network	G4	C3	TF-141
S201	Switch, Pushbutton	B4	A3	SW-435
S202	Switch, Pushbutton	A4	A3	SW-435
S203	Switch, Pushbutton	B4	B3	SW-435
S204	Switch, Pushbutton	B4	C3	SW-435
S205	Switch, Pushbutton	B4	C3	SW-435
S206	Switch, Pushbutton	A4	D3	SW-435
S207	Switch, Pushbutton	A4	D3	SW-435
S208	Switch, Pushbutton	B4	A4	SW-435
S209	Switch, Pushbutton	B4	B4	SW-435
S210	Switch, Pushbutton	A3	C4	SW-435
S211	Switch, Pushbutton	B3	C4	SW-435
S212	Switch, Pushbutton	B3	D4	SW-435
S213	Switch, Pushbutton	A3	D4	SW-435
U201	IC, Segment/Digit Driver, 75492	C3	B4	IC-169
U202	IC, Segment/Digit Driver, 75492	D4	C4	IC-169
U203	IC, 8-bit PI SO Shift Register, 74LS164	D5	D4	IC-127

Table 8-5. Model 1950 AC Option 1950-153, Parts List

Circuit Desig.	Description	Location Sch	Location Pcb	Keithley Part No.
C501	Capacitor, 10μF, 25V, Aluminum Electrolytic	H2	D1	C-314-10
C502	Capacitor, 10μF, 25V, Aluminum Electrolytic	H2	D2	C-314-10
C503	Capacitor, 10μF, 25V, Aluminum Electrolytic	H1	D2	C-314-10
C504	Capacitor, 1μF, 50V, Metalized Polycarbonate	E3	B2	C-215-1
C505	Capacitor, 1μF, 50V, Metalized Polycarbonate	F4	B2	C-215-1
C506	Capacitor, 1μF, 50V, Metalized Polycarbonate	F4	B2	C-215-1
C507	Capacitor, Variable, .25-1.5pF	C4	C3	C-184-.25/1.5p
C508	Capacitor, .1μF, 500V. Mica	D4	B3	C-278-110p
C509	Capacitor, Variable, .25-1.5pF	D4	C3	C-184-.25/1.5p
C510	Capacitor, .1μF, 1000V, Polyester Film	C4	D3	C-285-.1
C511	Capacitor, 33μF, 16V, Aluminum Electrolytic	E3	A3	C-321-33
C512	Capacitor, 33μF, 16V, Aluminum Electrolytic	E3	B3	C-321-33
C513	Capacitor, .1μF, 500V, Mica	D3	B3	C-278-610p
C514	Capacitor, 470pF, 1000V, Ceramic Disk	C2	C3	C-64-470p
C515	Capacitor, 15pF, 1000V, Ceramic Disk	D4	B3	C-64-15p
CR501	Rectifier, Bridge, 5A, 50PIV	B4	C2	RF-48
CR502	Rectifier, Silicon, 3A 50PIV, 1N4139	B4	D2	RF-34
CR503	Silicon Diode, 1N4148	C5	C2	RF-28
CR504	Silicon Diode, 1N4148	C5	C3	RF-28
K501	Relay, Reed	B3	B2	RL-49
K502	Relay, Reed	B3	C2	RL-50
K503	Relay, Reed	B2	C2	RL-59
K504	Relay	A4	D3	RL-72
K505	Relay, Reed, SPST	C4	C3	RL-57
K506	Relay, Reed, SPST	C3	C3	RL-57
P1004	Cable assembly, 14 Pin	H2	E2	CA-31-2
P1008	Connector, Pin		A1	CS-236
P1009	Connector, Pin		E2	CS-236
P1010	Connector, Pin		E1	CS-236
P1011	Connector, Pin		E3	CS-236
P1012	Connector, Pin		E3	CS-236
R501	Resistor, 10kΩ, 5%, 1/4W, Composition	G3	B1	R-76-10k
R502	Resistor, 10kΩ, 5%, 1/4W, Composition	G3	B1	R-76-10k
R503	Resistor, 100kΩ, 5%, 1/4W, Composition	B1	B2	R-76-100k
R504	Resistor, 100kΩ, 5%, 1/4W, Composition	B2	B2	R-76-100k
R505	Resistor, 100kΩ, 5%, 1/4W, Composition	C1	B2	R-76-100k
R506	Resistor, 100kΩ, 5%, 1/4W, Composition	C2	B2	R-76-100k
R507	Resistor, 0.1Ω, 0.1%, 7.5W, Wire Wound	B4	C2	R-262-0.1000
R508	Resistor, .898Ω, 0.1%, 5W, Wire Wound	B3	C2	R310-.898
R509	Resistor, 9Ω, 0.1%, 0.5W, Wire Wound	B3	D2	R-252-9
R510	Resistor, 900Ω, 0.1%, 1/8W, Metal Film	B1	D2	R-168-900
R511	Resistor, 24kΩ, 5%, 1/4W, Composition	F4	B3	R-76-24k
R512	Resistor, 2.2kΩ, 5%, 1/4W, Composition	F4	B3	R-76-2.2k
R513	Resistor, 90Ω, 0.1%, 1/2W, Metal Film	B2	C2	R-169-90
R514	Resistor, 100kΩ, 5%, 1/4W, Composition	E5	B3	R-76-100k
R515	Resistor, 2MΩ, 0.5%, 1/8W, Metal Film	D4	C3	R-246-2M
R516	Resistor, 20.2kΩ, 0.1%, 1/10W, Metal Film	D3	B3	R-263-20.2k
R517	Resistor, 90kΩ, 0.1%, 1/10W, Metal Film	E4	B3	R-263-90k
R518	Resistor, 4kΩ, 0.1%, 1/10W, Metal Film	D3	B3	R-263-4k
R519	Resistor, 10kΩ, 0.1%, 1/10W, Metal Film	E4	B3	R-263-10k
R520	Resistor, 24kΩ, 5%, 1/4W, Composition	E4	B3	R-76-24k
R521	Resistor, 5.6MΩ, 10%, 1/4W, Composition	E4	B3	R-76-5.6M

Table 8-5. Model 1950 AC Option 1950-153, Parts List (Cont.)

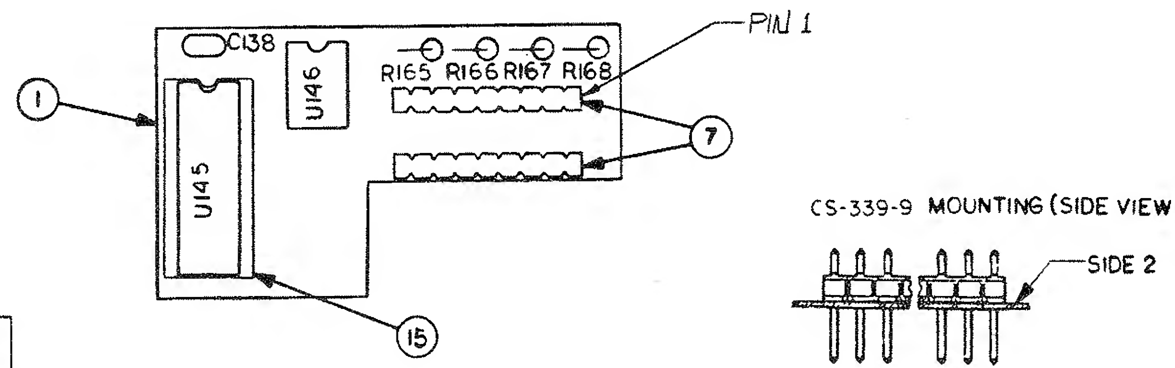
Circuit Desig.	Description	Location Sch	Location Pcb	Keithley Part No.
R522	Resistor, 2MΩ, 0.5%, 1W, Metal Film	C4	C3	R-303-2M
R523	Resistor, 5.1Ω, 5%, 1/4W, Composition	H1	D1	R-76-5.1
Q501	Transistor, Silicon, PNP, 2N3906	E5	B2	TG-84
Q502	FET, N-Channel	B1	B2	TG-128
Q503	FET, N-Channel	B2	B2	TG-151
Q504	FET, N-Channel	E5	B2	TG-128
Q505	FET, N-Channel	C2	B2	TG-128
Q506	FET, N-Channel	C2	B2	TG-128
U501	IC, Quad Comparator, LM339	F3	B1	IC-219
U502	IC, Dual Decoder/Multiplexer MC14555	G5	C1	IC-312
U503	IC, Darlington Array, ULN2003A	G6	C1	IC-206
U504	IC, MC14094B	G4	C1	IC-251
U505	IC, JFET, OP Amp, LF351N	C1	B2	IC-176
U506	IC, JFET, OP, Amp	D5	C2	IC-196
U507	IC, TRMS to DC Converter, AD536AK	E4	B3	IC-305
U508	IC, JFET, OP Amp, LF351N	D4	B3	IC-176

Table 8-6. Mechanical Parts

Description	Qty.	Location	Keithley Part No.
Cover, Bottom	1	Case	30541
Bail, Tilt	1	Case	30544
Feet	4	Bottom Cover	FE-14
Collar, Insulating	4	Inside Bottom Case	30545
Spacer	2	Inside Bottom Case	31843-1
Cover, Top	1	Case	30540
Panel, Front	1	Front Panel	195-301
Window	1	Front Panel	30537
Overlay, Front Panel	1	Front Panel	195A-301
Binding Post, Black	4	Front Panel, Rear Panel	BP-11-0
Binding Post, Red	4	Front Panel, Rear Panel	BP-11-2
Binding Post, White	2	Front Panel, Rear Panel	BP-11-9
Pushbutton, Yellow Brown	3	Front Panel	31470-4
Pushbutton, Light Brown	5	Front Panel	31470-5
Pushbutton, Brown	5	Front Panel	31470-6
Panel, Rear	1	Rear Panel	195-307
Connector, BNC	2	Rear Panel	CS-249
Line Cord	1	Rear Panel	CO-7
Pushbutton, Power Switch	1	Front Panel	29465-3
Shield, Analog	1	Mother Board	195-308
Shield, Bottom	1	Mother Board	195-309

195-160 NO

LTR.	ECO NO.	REVISION	ENG.	DATE
A	9382	RELEASED	—	9-30-83
B	10040	ITEM 12 WAS 267 K	[illegible]	7-3-84
C	10152	UPDATED PER REV B ART	[illegible]	9-12-84



ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	195-162		B1
2			
3			
4	C237-.1	C138	C1
5			
6			
7	CS-339-9	~~2 REQ'D~~	E2
8			
9			
10	R76-10K	R165	D1
11	R88-61.9K	R166	D1
12	R88-1M	R167	D1
13	R88-20K	R168	D1
14			
15	50-82	1 REQ'D	D2
16	LSI-50	U145	C2
17	IC-177	U146	C1
18			

MODEL	NEXT ASSEMBLY	QTY.
195T		1
195		1

USED ON

DO NOT SCALE THIS DRAWING

KEITHLEY Keithley Instruments Inc. Cleveland, Ohio 44139

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX = ± .015 ANG. = ±1°
XXX = ± .005 FRAC. = ±1/64
SURFACE MAX. 63

DATE 2-28-83 SCALE 2:1
DRN. CB ENG. APPR. DJA
MATERIAL
FINISH

TITLE COMPONENT LAYOUT

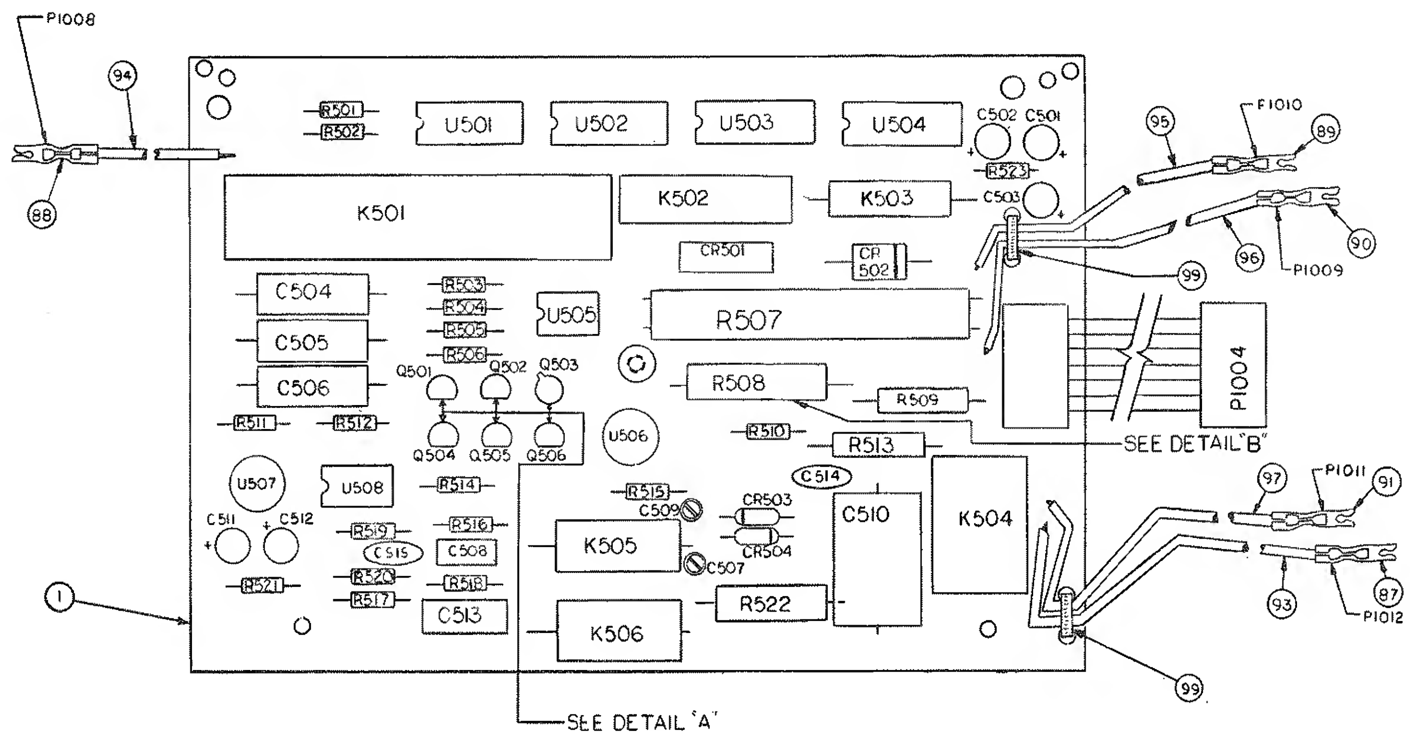
SIZE B NO. 195-160

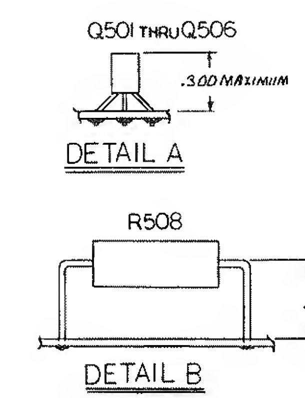
FORM 232778 REV. D

Figure 8-2. NVRAM Modifications Board, Component Location Drawing, Dwg. No. 195-160

1950-150

ZONE	LTR	ECO NO	REVISION	DATE
	A	[illegible]	RELEASED	[illegible]
	B	9204	[illegible]	[illegible]
	C	[illegible]	[illegible]	[illegible]
	D	[illegible]	ITEM 81 WAS IC-2[illegible]	[illegible]
	E	9951	ITEM 6 WAS C-2[illegible]. ITEM 20 WAS CA-9-2.	6-1-84
	F	10117	CHG'D ARTWORK FROM REV. E TO REV. F	8-7-84
	G	10689	CHG'D ARTWORK FROM REV. F to G.	8-20-85
	H	11299	ITEM 45 WAS R-232-.898	5-7-85





ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	1950-151	STAKING	A3
2			
3	C-314-10	C501	D1
4	C-314-10	C502	D2
5	C-314-10	C503	D2
6	C-335-1.2	C504	B2
7	C-215-1	C505	B2
8	C-215-1	C506	B2
9	C-184-25/15p	C507	C3
10	C-278-110p	C508	B3
11	C-184-25/15p	C509	C3
12	C-285-.1	C510	D3
13	C-321-33	C511	A3
14	C-321-33	C512	B3
15	C-278-610p	C513	B3
16	C-64-470p	C514	C3
17	C-64-15p	C515	B3
18			
19			
20	CA-31-2	P1004	E2
21			
22	RF-48	CR501	C2
23	RF-34	CR502	D2
24	RF-28	CR503	C2
25	RF-28	CR504	C3
26			
27			
28			
29	RL-49	K501	B2
30	RL-50	K502	C2
31	RL-59	K503	C2
32	RL-72	K504	D3
33	RL-57	K505	C3

ITEM	PART NO.	SCHEM. DESIG.	ZONE
34	RL-57	K506	C3
35			
36			
37			
38	R-76-10K	R501	B1
39	R-76-10K	R502	B1
40	R-76-100K	R503	B2
41	R-76-100K	R504	B2
42	R-76-100K	R505	B2
43	R-76-100K	R506	B2
44	R-262-0.1000	R507	C2
45	R-310-.898	R508	C2
46	R-252-9	R509	D2
47	R-168-900	R510	C2
48	R-76-24K	R511	B3
49	R-76-2.2K	R512	B3
50	R-169-90	R513	C2
51	R-76-100K	R514	B3
52	R-246-2M	R515	C3
53	R-263-20.2K	R516	B3
54	R-263-30K	R517	B3
55	R-263-4K	R518	B3
56	R-263-10K	R519	B3
57	R-76-24K	R520	B3
58	R-76-5.6M	R521	B3
59	R-303-2M	R522	C3
60	R-76-5.1	R523	D1
61			
62			
63			
64			
65			
66			

ITEM	PART NO.	SCHEM. DESIG.	ZONE
67	TG-84	Q501	B2
68	TG-128	Q502	B2
69	TG-151	Q503	B2
70	TG-128	Q504	B2
71	TG-128	Q505	B2
72	TG-125	Q506	B2
73			
74			
75			
76			
77			
78	IC-219	U501	B1
79	IC-312	U502	C1
80	IC-206	U503	C1
81	IC-251	U504	C1
82	IC-176	U505	B2
83	IC-196	U506	C2
84	IC-305	U507	B3
85	IC-176	U508	B3
86			
87	CS-236	P1012	E3
88	CS-236	P1008	A1
89	CS-236	P1010	E1
90	CS-236	P1009	E2
91	CS-236	P1011	E3
92			
93	SC-55 (YEL)	—	E3
94	SC-55 (WHT)	—	A1
95	SC-55 (BLK)	—	E1
96	SC-55 (BL)	—	E2
97	SC-55 (RED)	—	E3
98			
99	CC-38-2	2 REQ'D	D2, D3

ITEM	PART NO.	SCHEM. DESIG.	ZONE
100			
101			
102			
103			
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131			
132			

FORM 28511B REV C

MODEL	NEXT ASSEMBLY	QTY
1950		

USED ON

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DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

DATE 5-1-84 | SCALE 2:1 | DRN MH | ENG APPR [illegible]

MATERIAL

FINISH

TITLE COMPONENT LAYOUT, A.C. OPTION BOARD

SIZE D | NO. 1950-150

Figure 8-3. Model 1950 AC Option, Component Location Drawing, Dwg. No. 1950-150

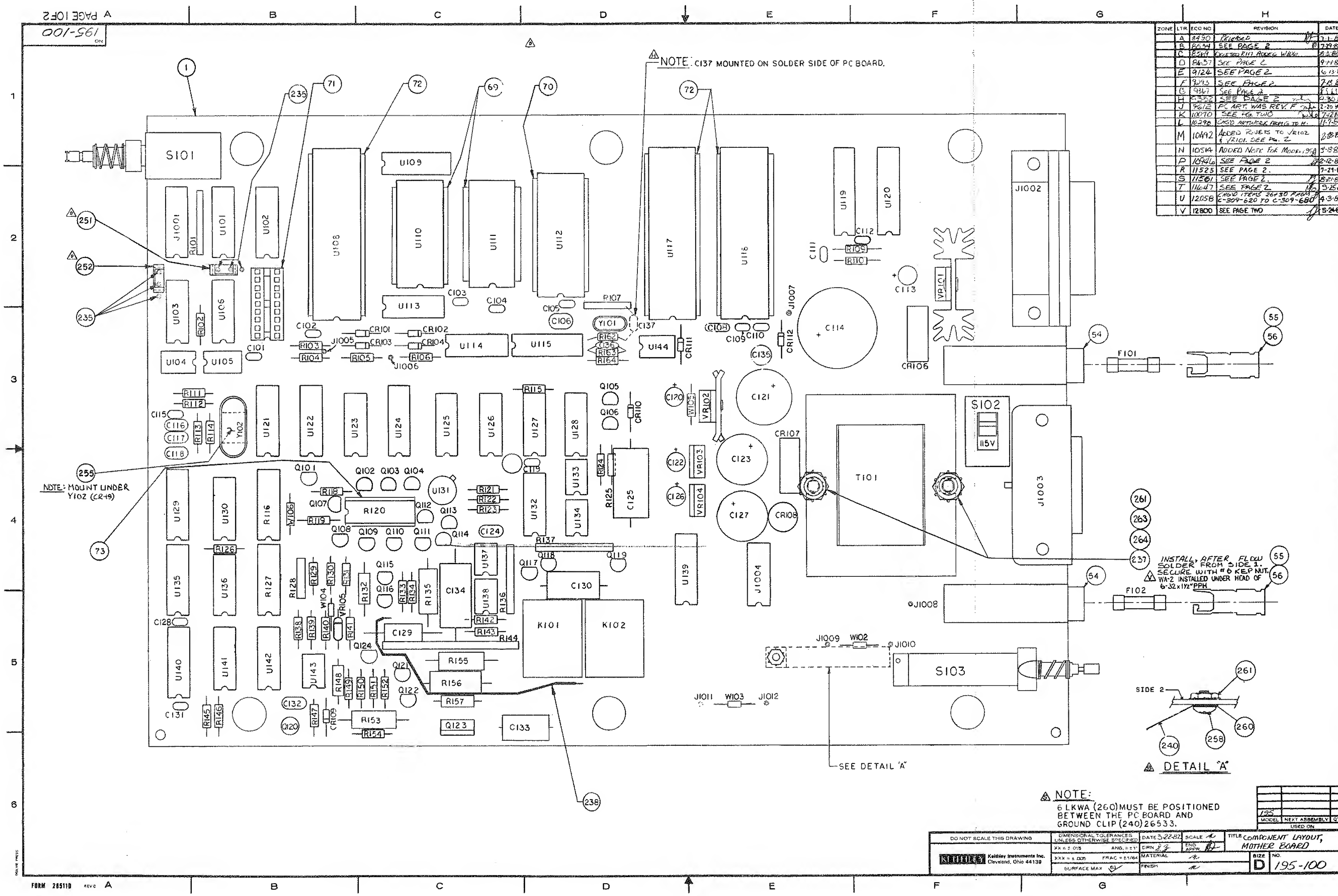


Figure 8-4. Mother Board, Component Location Drawing, Dwg. No. 195 -100 (sheet 1 of 2)

195-100

A PAGE 2 OF 2

ZONE	LTR	ECO NO	REVISION	DATE
	A	8490	RELEASED	7-1-82
	B	8534	DELETED ITEM 53, FU-13. ADDED THE FOLLOWING ITEMS: NO'S: 175, TR-196; 241, FU-29; 242, FU-32; 243, FU-40; 244, FU-31; 245, FU-13; 246, FU-48.	7-29-82
	C	8569	DELETED ITEM 124 ADDED ITEM 250	8-3-82
	D	8637	CHG'D ARTWORK FROM REV C TO D. ADDED ITEM 37 C-138-3600pF. ITEM 190 WAS R-282-910K. ITEM 163 WAS R-264-1,000K. ITEM 236 WAS CS-447 2 REQ'D. ADDED ITEMS 251 & 252	9-14-82
	E	9124	DELETED ITEMS #10, #47, #115, #192. ADDED ITEMS #38, #41, #42, 165, #166, #167, #220. CHG'D NETWORK BACKING FROM REV. D TO REV F	6-13-83
	F	9293	ITEMS 89, 93 & 94 WERE TG-139. ITEM 75 WAS RL-72	7-13-83
	G	9361	ITEM 140 WAS R-282-806K. ITEM 141 WAS R-88-909K	9-5-83
	H	9382	ADDED ITEMS 39 (C136) AND 40 (C137) AND ... ITEMS ...	9-30-83
	J	9612	SEE PAGE 1 OF 1	2-7-84
	K	10070	ITEM 75 WAS 195-601	7-12-84
	L	10296	SEE PAGE 1.	11-7-84
	M	10492	CHG'D ITEM 223 FROM IC-3-7 TO 32469-3. CHG'D ITEM 224 FROM IC-... TO 32468-1. DELETED 233 & 234	2-28-85
	N	10514	SEE PAGE 1 OF 1	3-13-85
	P	10946	ITEM 169 - DELETED SW-426, ADDED SW-466.	2-12-86
	R	11525	CHG'D ARTWORK FROM REV H TO J.	7-29-86
	S	11561	ADDED ITEMS 258, 260 & 261. ADDED DETAIL AND NOTE FOR GROUND CLIP. CHG'D ITEMS 229 THRU 231 FROM J-3 TO J-15. DELETED ITEM 228 FROM LAYOUT	8-21-86
	T	11647	Q109, Q113 & Q114 WERE 195-600. Q103, Q102, Q110 & Q111 WERE TG-139	9-25-86
	U	12058	CHG'D ITEMS 26 & 30 FROM C-309-620 TO C-309-680	4-3-87
	V	12800	CHG'D ITEM 237 FROM FA-147(2) TO 6-32x1½ PPH(2), CHG'D QTY. OF ITEM 261 FROM 1 TO 3. ADDED ITEM 264	5-24-88

ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	STAKING	195-101	
2			
3			
4	C-237-0.1	C101	B3
5	"	C102	B3
6	"	C103	C2
7	"	C104	C2
8	"	C105	D2
9	C-64-22p	C106	D3
10			
11	C-64-22p	C108	E3
12	C-237-0.1	C109	E3
13	"	C110	E3
14	"	C111	E2
15	"	C112	F2
16	C-314-10	C113	F2
17	C-342-10,000	C114	E3
18	C-237-0.1	C115	A3
19	C-22-6800p	C116	A3
20	C-22-150p	C117	A3
21	C-22-33p	C118	A4
22	C-237-0.1	C119	D4
23	C-314-10	C120	D3
24	C-314-2200	C121	E3
25	C-314-10	C122	D3
26	C-309-680	C123	E3
27	C-22-33p	C124	C4
28	C-138-3600	C125	D4
29	C-314-10	C126	D4
30	C-309-680	C127	E4
31	C-237-0.1	C128	A5
32	C-138-330	C129	C5
33	C-138-1500	C130	D4
34	C-237-0.1	C131	A5
35	C-64-150pF	C132	B5
36	C-138-1000	C133	C5
37	C-138-3600pF	C134	C5
38	C-314-10	C135	E3
39	C-22-.01	C136	D3
40	C-237-.1	C137	D3

ITEM	PART NO.	SCHEM. DESIG.	ZONE
41	RF-28	CR111	D3
42	"	CR112	E3
43	RF-28	CR101	C3
44	"	CR102	C3
45	"	CR103	C3
46	"	CR104	C3
47			
48	RF-48	CR106	F3
49	"	CR107	E3
50	RF-46	CR108	E4
51	RF-38	CR109	B5
52	RF-28	CR110	D3
53			
54	FH-21	2 REQ'D	G3,G5
55	FH-25 *† OR	2 REQ'D	G3,G5
56	FH-26	2 REQ'D	G3,G5
57	SO-65	J1001	A2
58	CS-443	J1002	G2
59	CS-388	J1003	G4
60	SO-70	J1004	E4
61	24249A	J1005	B3
62	"	J1006	C3
63	"	J1007	E3
64	"	J1008	F5
65	"	J1009	E5
66	"	J1010	F5
67	"	J1011	D5
68	"	J1012	E5
69	SO-68 ⊠	2 REQ'D	D1
70	SO-69	1 REQ'D	D1
71	SO-82	J1013	B1
72	SO-84-40	3 REQ'D	C,D,E1
73	SO-65	1 REQ'D	C4
74			
75	RL-72	K101	D5
76	RL-72	K102	D5
77			
78	CR-10	Y101	D3
79	CR-19	Y102	B3
80			

ITEM	PART NO.	SCHEM. DESIG.	ZONE
81	TG-47	Q101	B4
82	193-603	Q102	B4
83	193-603	Q103	C4
84	TG-139	Q104	C4
85	TG-84	Q105	D3
86	"	Q106	D3
87	TG-139	Q107	B4
88	"	Q108	B4
89	193-603	Q109	C4
90	193-603	Q110	C4
91	193-603	Q111	C4
92	TG-139	Q112	C4
93	193-603	Q113	C4
94	193-603	Q114	C4
95	31841	Q115	C4
96	TG-128	Q116	C5
97	"	Q117	C4
98	"	Q118	D4
99	"	Q119	D4
100	TG-39	Q120	B5
101	31841	Q121	C5
102	"	Q122	C5
103	TG-137	Q123	C5
104	TG-139	Q124	C5
105			
106			
107			
108	TF-100	R101	B2
109	R-76-220	R102	B3
110	R-76-10K	R103	B3
111	R-76-330	R104	B3
112	R-76-100	R105	C3
113	"	R106	C3
114	TF-101	R107	D2
115			
116	R-246-249	R109	F2
117	R-246-750	R110	F2
118	R-76-220	R111	B3
119	R-76-330	R112	B3
120	R-76-15M	R113	B3

ITEM	PART NO.	SCHEM. DESIG.	ZONE
121	R-76-2.2K	R114	B3
122	R-76-10K	R115	D3
123	TF-108	R116	B4
124			
125	R-282-910K	R118	B4
126	"	R119	B4
127	TF-146	R120	C4
128	R-76-100K	R121	C4
129	R-76-1K	R122	C4
130	R-88-11K	R123	C4
131	R-88-1M	R124	D3
132	R-88-6.34K	R125	D4
133	R-76-1M	R126	B4
134	TF-108	R127	B4
135	TF-150	R128	B4
136	R-282-910K	R129	B4
137	"	R130	B4
138	"	R131	B4
139	R-1-220K	R132	C5
140	R-88-806K	R133	C5
141	R-88-909K	R134	C5
142	R-2-910K	R135	C5
143	TF-149	R136	D5
144	TF-85	R137	D4
145	R-76-7.5K	R138	B5
146	R-88-6.19K	R139	B5
147	R-88-1.54K	R140	B5
148	R-88-10.7K	R141	B5
149	R-88-7.5K	R142	C5
150	R-88-12.7K	R143	C5
151	TF-148	R144	C5
152	R-76-10K	R145	B5
153	"	R146	B5
154	R-76-3.3K	R147	B5
155	R-1-220K	R148	B5
156	R-76-1M	R149	B5
157	"	R150	C5
158	"	R151	C5
159	"	R152	C5
160	R-2-100K	R153	C5

ITEM	PART NO.	SCHEM. DESIG.	ZONE
161	R-76-10K	R154	C5
162	R-3-680K	R155	C5
163	R-315-1,000K	R156	C5
164	R-263-100K	R157	C5
165	R-88-6.19K	R162	D3
166	R-88-1M	R163	D3
167	R-88-20K	R164	D3
168			
169	SW-466	S101	B1
170	SW-425	S102	F3
171	SW-443	S103	F5
172			
173			
174	TR-194 OR	T101 *†	F4
175	TR-196	T101	F4
176			
177	IC-250	U101	B2
178	"	U102	B2
179	IC-179	U103	A2
180	IC-292	U104	A3
181	"	U105	B3
182	IC-144	U106	B2
183			
184	LSI-28	U108	B2
185	IC-190	U109	C2
186	LSI-51	U110	C2
187	195-800	U111 ⊠	C2
188	195-801	U112 ⊠	D2
189	IC-186	U113	C3
190	IC-163	U114	C3
191	IC-280	U115	D3
192			
193	LSI-27	U117	D2
194	LSI-49	U118	E2
195	IC-298	U119	E2
196	IC-299	U120	F2
197	IC-106	U121	B3
198	IC-197	U122	B3
199	IC-138	U123	B3
200	IC-324	U124	C3

ITEM	PART NO.	SCHEM. DESIG.	ZONE
201	IC-103	U125	C3
202	IC-179	U126	C3
203	IC-216	U127	D3
204	29198	U128	D3
205	IC-251	U129	A4
206	IC-219	U130	B4
207	30167	U131	C4
208	29198	U132	D4
209	IC-173	U133	D4
210	IC-176	U134	D4
211	IC-135	U135	A4
212	IC-219	U136	B4
213	IC-42	U137	C4
214	IC-246	U138	C5
215	IC-206	U139	E4
216	IC-251	U140	A5
217	IC-219	U141	B5
218	"	U142	B5
219	IC-246	U143	B5
220	IC-177	U144	D3
221			
222			
223	32469-3	VR101	F2
224	32468-1	VR102	E3
225	IC-194	VR103	E4
226	IC-195	VR104	E4
227	DZ-58	VR105	B5
228			
229	J-15	W102	F5
230	"	W103	E5
231	"	W104	B5
232	J-3	W105	E3
233			
234			
235	24249A	6 REQ'D.	~
236			
237	6-32x1½ PPH	2 REQ'D	E,F4
238	SC-55		D6
239			
240	26533A	1 REQ'D	F6

ITEM	PART NO.	SCHEM. DESIG.	ZONE
241	FU-29 OR	F101 *	G3
242	FU-32	F101	G3
243	FU-40 OR	F101 †	G3
244	FU-31	F101	G3
245	FU-13 OR	F102 *†	G5
246	FU-48	F102	G5
247			
248			
249			
250	J-3	W106	B4
251	CS-447	W107	B2
252	"	W108	A2
253			
254			
255	27493-26	1 REQ'D	A4
256			
257			
258	6-32x¼ PPH	1 REQ'D	E5
259			
260	6 LKWA	1 REQ'D	E5
261	6-32 KEPNUT	3 REQ'D	E5,E4,F4
262			
263	WA-2	2 REQ'D	E4, F4
264	#8 TEFLON TUBING	2 PLACES	E4, F4
265			
266			
267			
268			
269			
270			
271			
272			
273			
274			
275			
276			
277			
278			
279			
280			

* FOR U.S. 115V. OPERATION.
† FOR U.S. 230V. OPERATION.
⊠ U111 & Qty. 1 SO-68 Not Used for Model 175A. U112 195A-800 for Model 195A

195			
MODEL	NEXT ASSEMBLY	QTY	
USED ON			

DO NOT SCALE THIS DRAWING

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: XX ± .015, ANG ± 2°, XXX ± .005, FRAC ± 1/64, SURFACE MAX

DATE 3-22-81 | SCALE | DRN | ENG APPR | MATERIAL | FINISH

KEITHLEY Keithley Instruments Inc. Cleveland, Ohio 44139

TITLE COMPONENT LAYOUT MOTHER BOARD

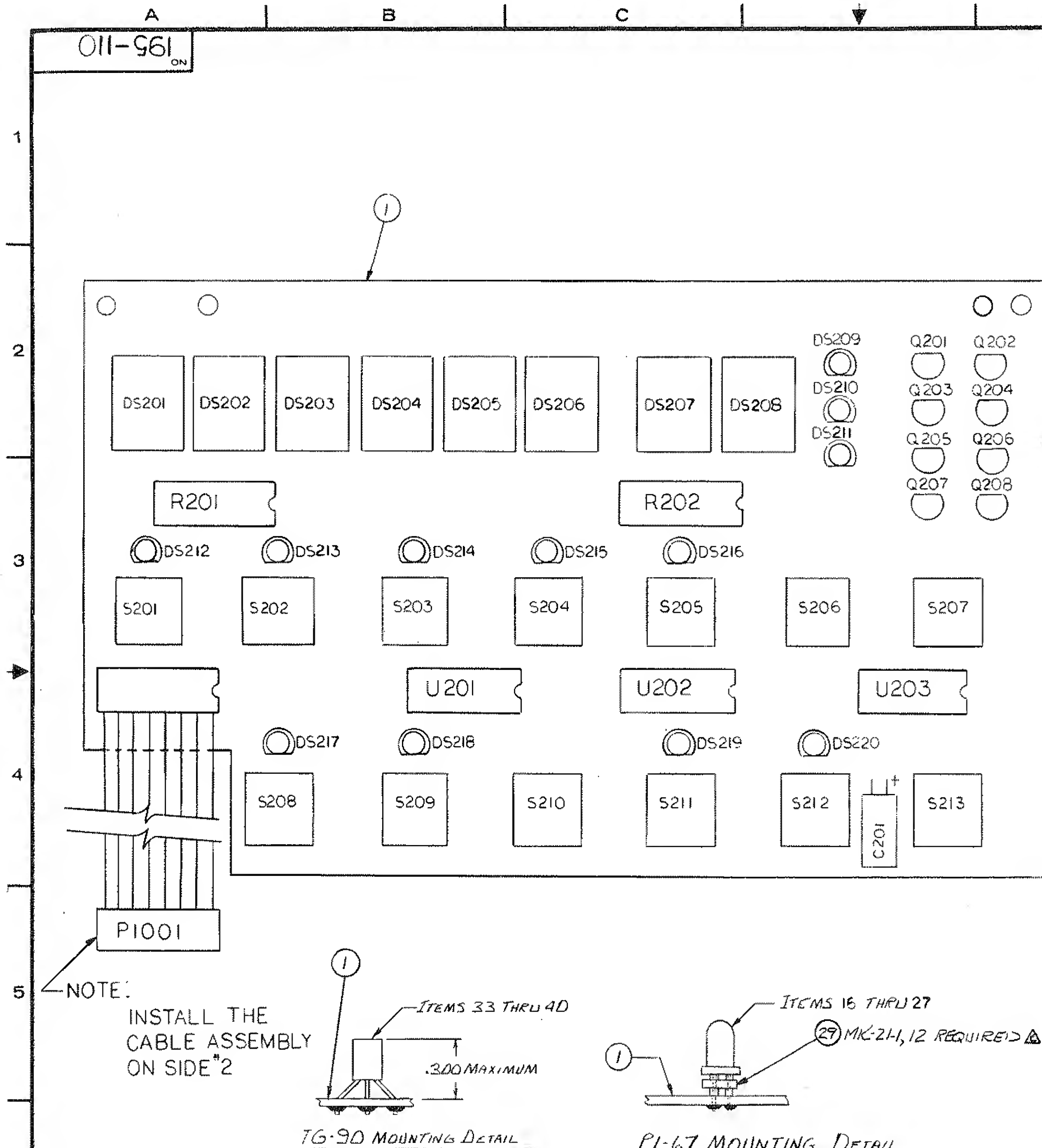
SIZE D | NO 195-100

FORM 26511D REV C

H PAGE 2 OF 2

Figure 8-4. Mother Board, Component Location Drawing, Dwg. No. 195 -100 (sheet 2 of 2)

ZONE	LTR	ECO NO	REVISION	DATE
	A	[illegible]	[illegible]	[illegible]
	B	[illegible]	[illegible]	[illegible]
	C	8851	[illegible]	[illegible]
	D	8966	CHG'D ITEM 47 FROM TF-141 TO TF-165-1	[illegible]
	E	9809	ADDED ITEM 29	5/30/84



ITEM	PART NO	SCHEM DESIG.	ZONE
1	195-112	HOLE SIZE	B1
2			
3	C-179-10	C201	D4
4	CA-15-2	P1001	A3
5			
6			
7			
8	DD-31	DS201	A2
9	DD-30	DS202	A2
10	"	DS203	B2
11	"	DS204	B2
12	"	DS205	C2
13	DD-30	DS206	C2
14	DD-31	DS207	C2
15	DD-30	DS208	D2
16	PL-67	DS209	D2
17	"	DS210	D2
18	"	DS211	A3
19	"	DS212	B3
20	"	DS213	B3
21	"	DS214	C3
22	"	DS215	C3
23	"	DS216	B4
24	"	DS217	B4
25	"	DS218	C4
26	"	DS219	C4
27	"	DS220	D4
28			
29	MK-21-1	12 REQ'D	—
30			
31			
32			
33	TG-90	Q201	D2
34	"	Q202	E2
35	"	Q203	D2
36	"	Q204	E2
37	"	Q205	D3
38	"	Q206	E3
39	"	Q207	D3
40	"	Q208	E3

ITEM	PART NO.	SCHEM DESIG.	ZONE
41			
42			
43			
44			
45			
46	TF-77	R201	A3
47	TF-165-1	R202	C3
48			
49			
50			
51	SW-435	S201	A3
52	"	S202	A3
53	"	S203	B3
54	"	S204	C3
55	"	S205	C3
56	"	S206	D3
57	"	S207	D3
58	"	S208	A4
59	"	S209	B4
60	"	S210	C4
61	"	S211	C4
62	"	S212	D4
63	"	S213	D4
64			
65			
66			
67	IC-169	U201	B4
68	IC-169	U202	C4
69	IC-127	U203	D4
70			
71			
72			
73			
74			
75			
76			
77			
78			
79			
80			

MODEL	NEXT ASSEMBLY	QTY
195A		

USED ON

DO NOT SCALE THIS DRAWING

KEITHLEY Keithley Instruments Inc. Cleveland Ohio 44139

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

DATE 6/1/84 SCALE 2-1 DRN ENG APPR MATERIAL FINISH

TITLE COMPONENT LAYOUT (DISPLAY BOARD)

SIZE C NO 195-110

Figure 8-5. Display Board, Component Location Drawing, Dwg. No. 195-110

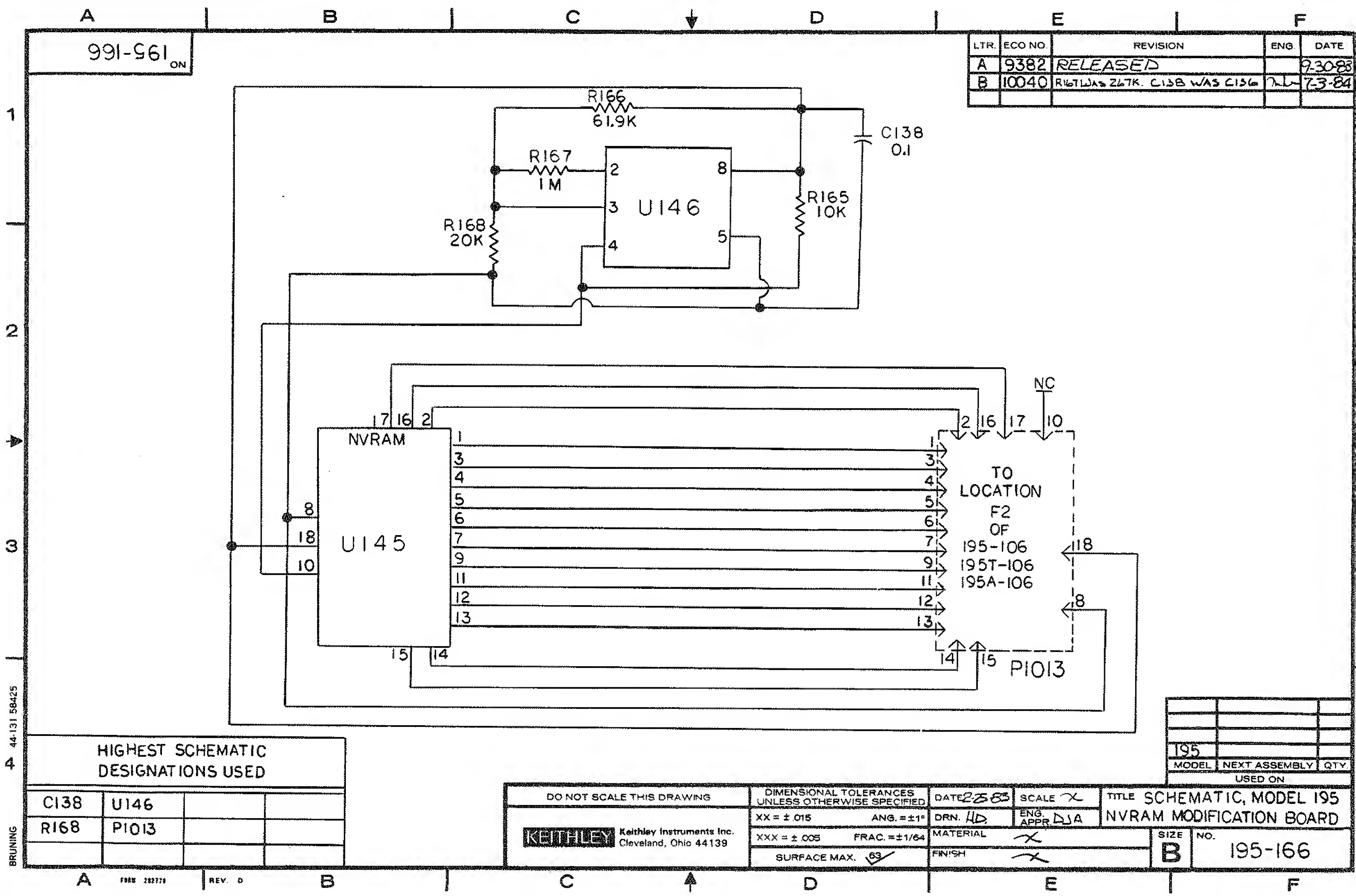


Figure 8-6. NVRAM Modifications Board, Schematic Diagram, Dwg. No. 195-166

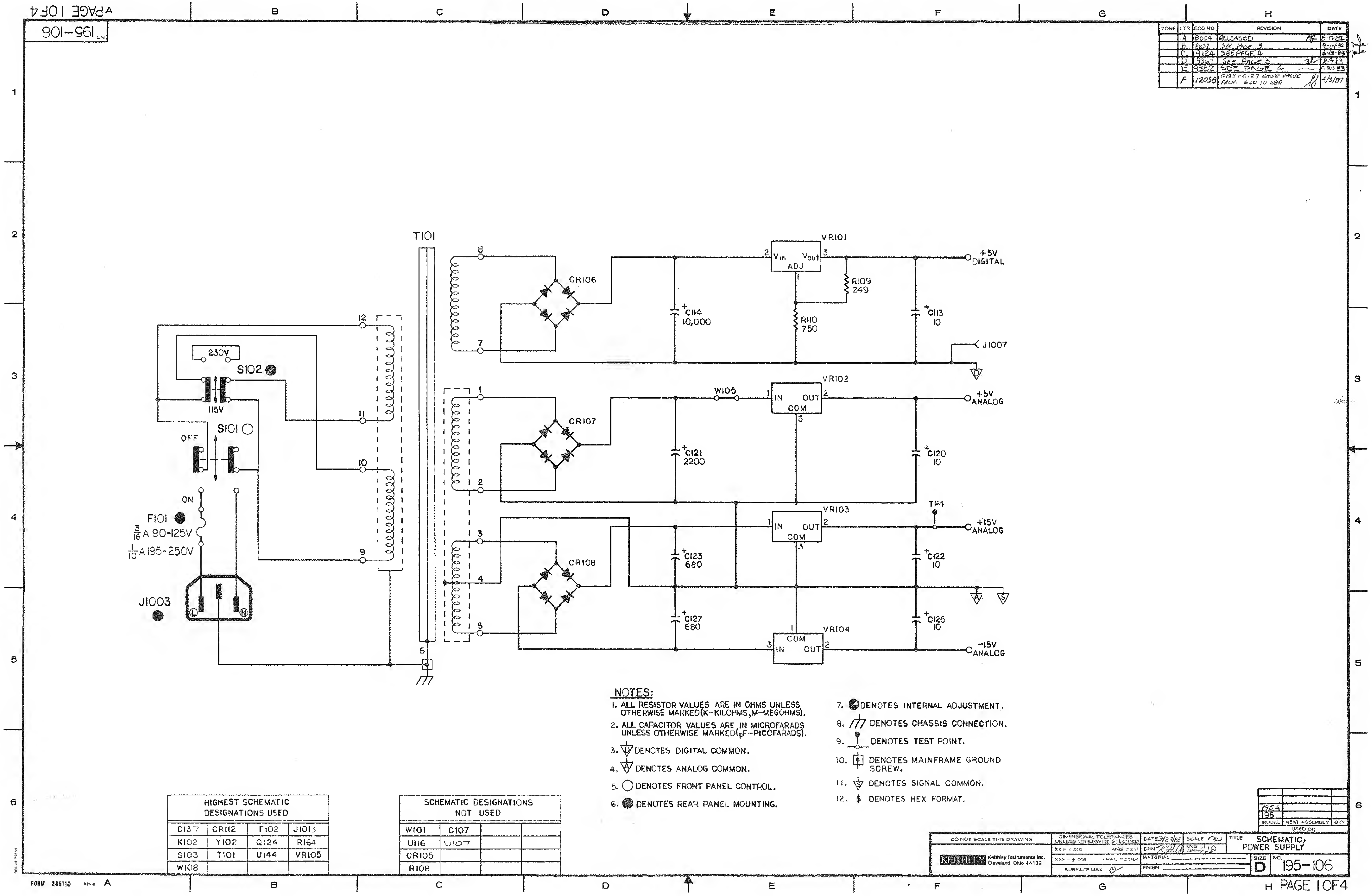


Figure 8-7. Mother Board, Schematic Diagram, Dwg. No. 195-106 (sheet 1 of 4)

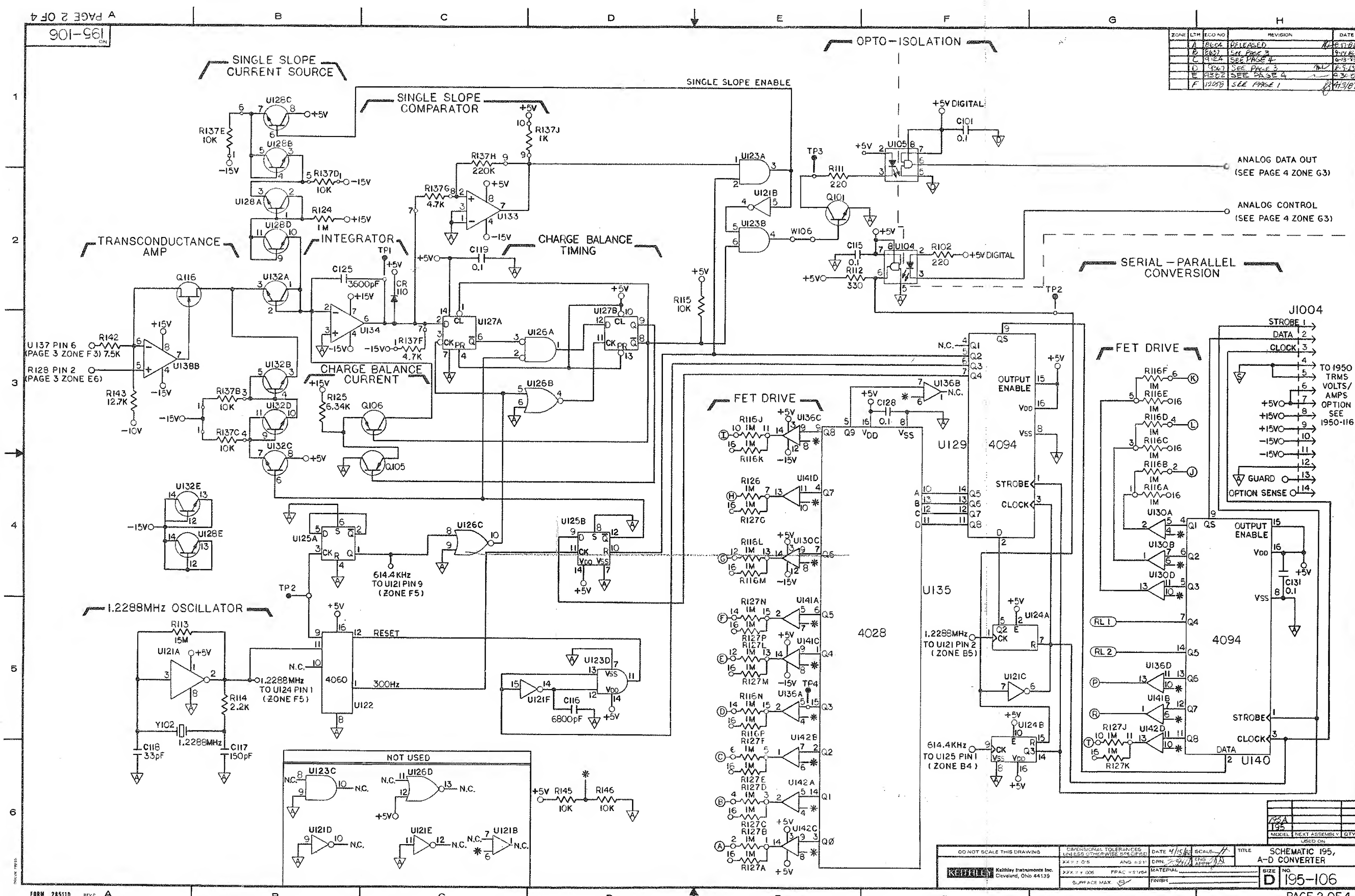


Figure 8-7. Mother Board, Schematic Diagram, Dwg. No. 195-106 (sheet 2 of 4)

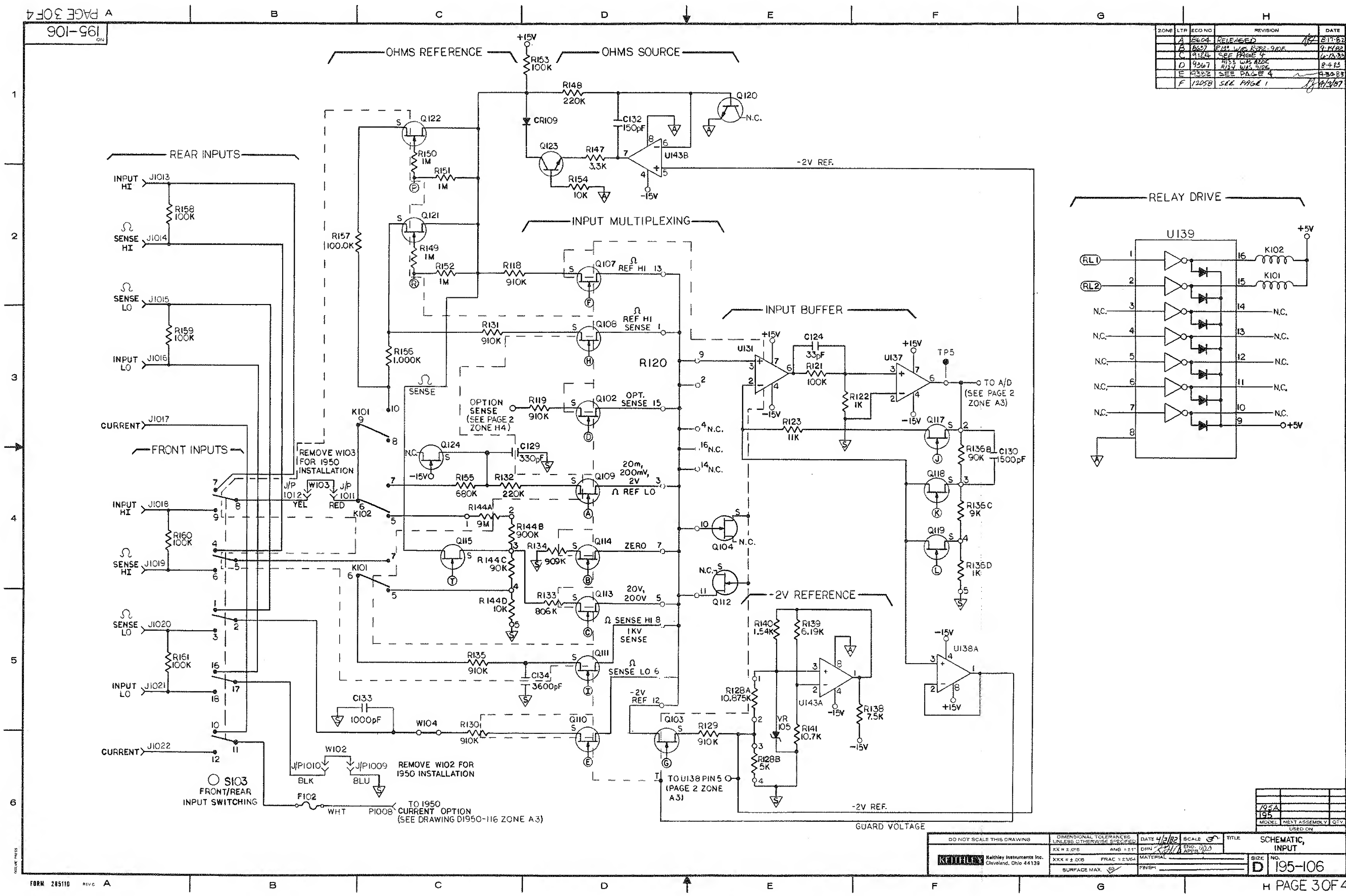


Figure 8-7. Mother Board, Schematic Diagram, Dwg. No. 195-106 (sheet 3 of 4)

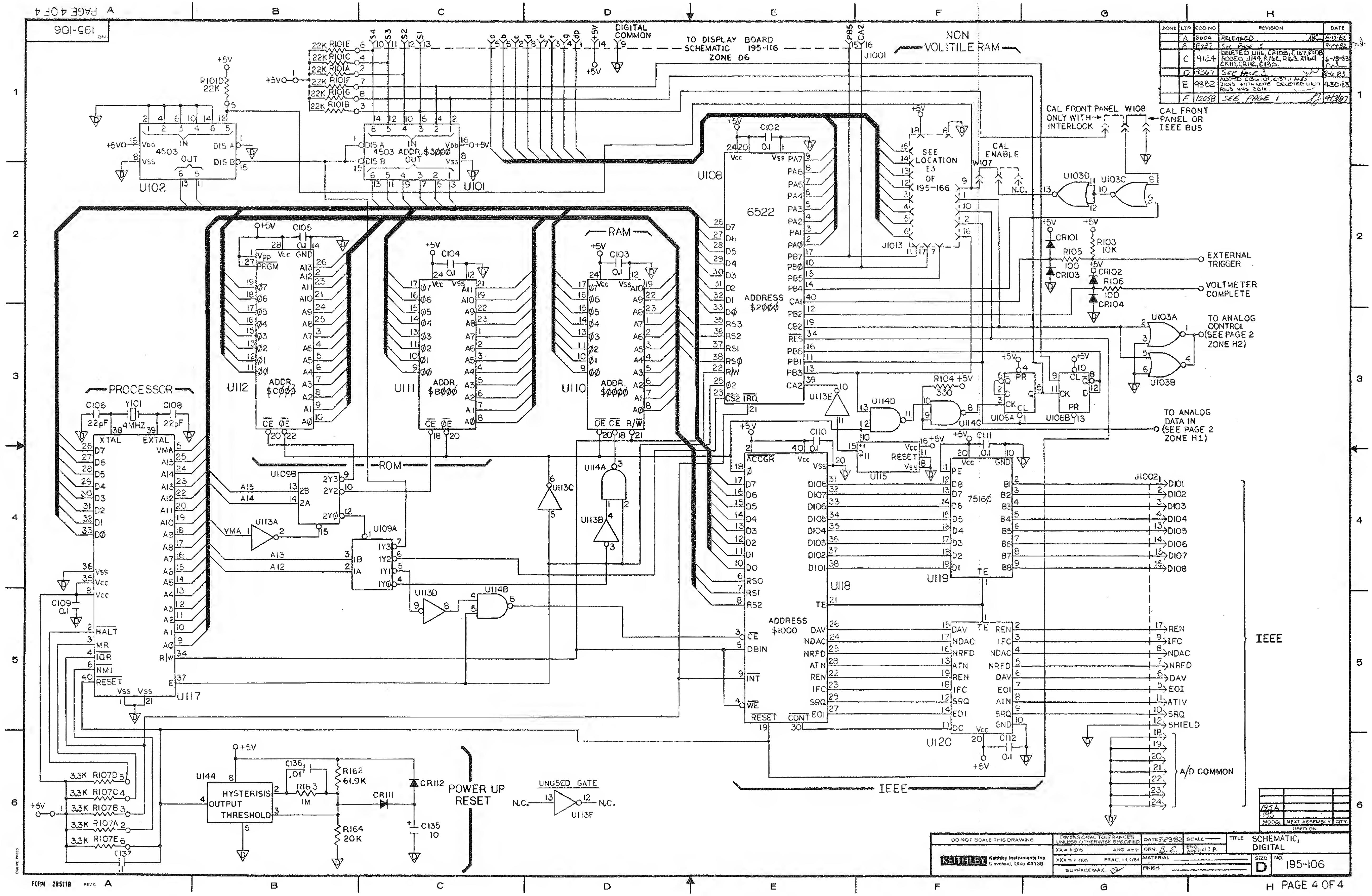


Figure 8-7. Mother Board, Schematic Diagram, Dwg. No. 195-106 (sheet 4 of 4)

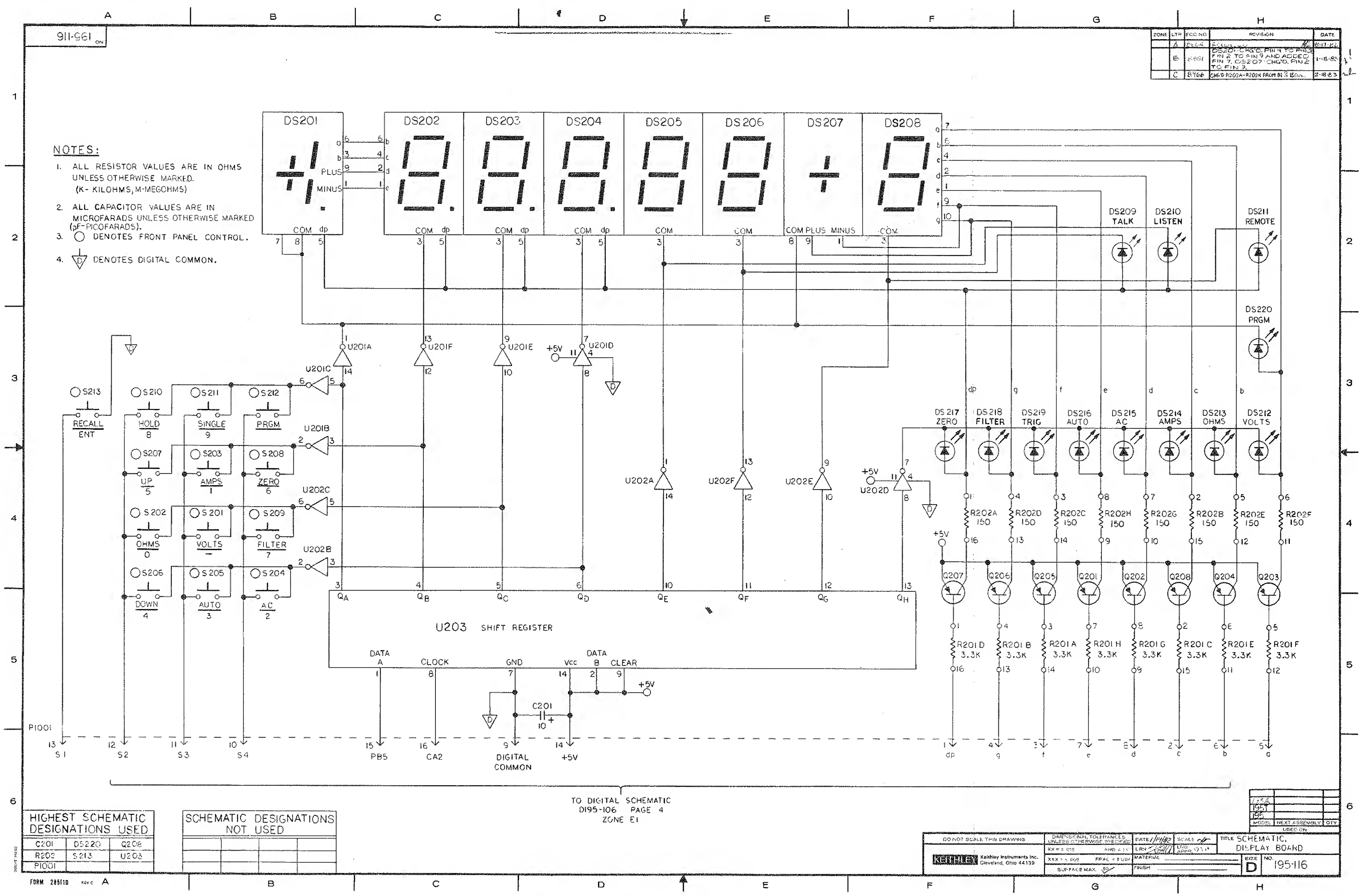


Figure 8-8. Display Board, Schematic Diagram, Dwg. No. 195-116

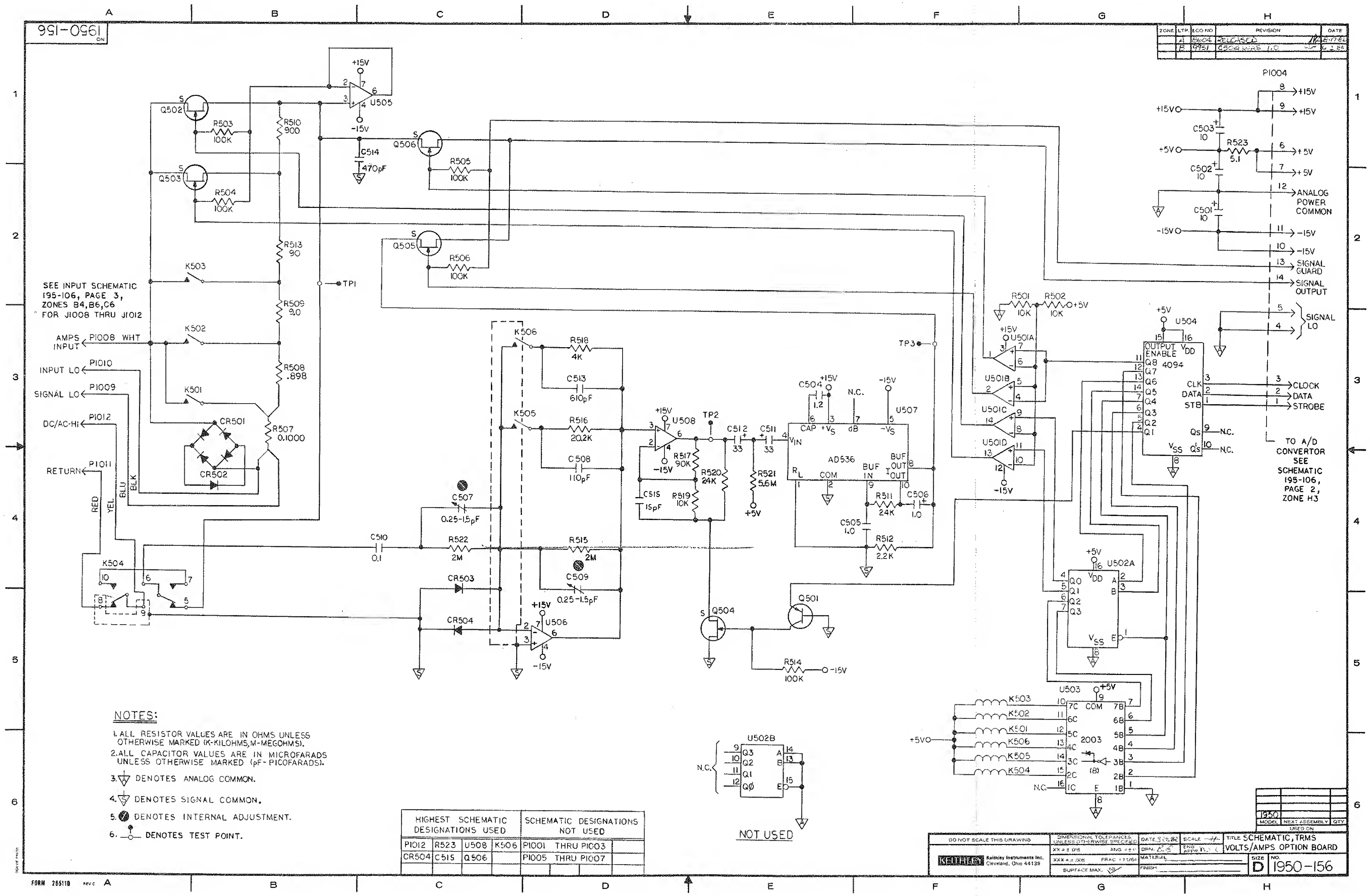


Figure 8-9. Model 1950 AC Option, Schematic Diagram, Dwg. No. 1950-156

KEITHLEY

SERVICE FORM

Model No. ______________ **Serial No.** ____________________ **Date** __________

Name and Telephone No. ____

Company ____

List all control settings, describe problem and check boxes that apply to problem. ____________________

____

____

☐ Intermittent ☐ Analog output follows display ☐ Particular range or function bad; specify __________

☐ IEEE failure ☐ Obvious problem on power-up ☐ Batteries and fuses are OK

☐ Front panel operational ☐ All ranges or functions are bad ☐ Checked all cables

Display or output (circle one)

☐ Drifts ☐ Unable to zero

☐ Unstable ☐ Will not read applied input

☐ Overload

☐ Calibration only ☐ C of C required

☐ Data required

(attach any additional sheets as necessary.)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

____

____

What power line voltage is used? ______________ Ambient Temperature? __________ °F

Relative humidity? __________ Other? ______________________________

Any additional information. (If special modifications have been made by the user, please describe.) __________

____

Be sure to include your name and phone number on this service form.